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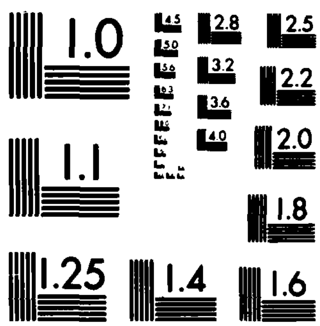

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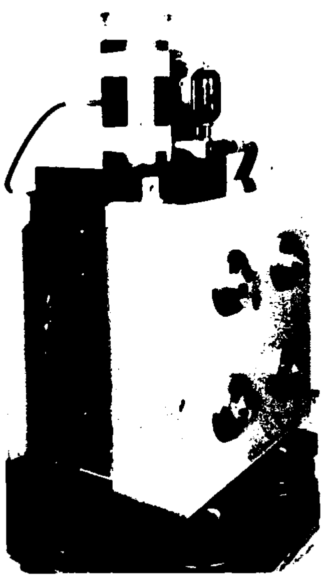

GEOTECHNICAL LABORATORY

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RATIONALIZING THE SEISMIC COEFFICIENT METHOD

by

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The seismic stability of embankment dams may be evaluated by a relatively simple method, originally proposed by N. M. Newmark, in cases where there is no threat of liquefaction or severe loss of shear strength under seismic shaking. This method is based on idealization of the potential slide mass as a sliding block on an inclined plane which undergoes a history of earthquake-induced accelerations. The result is a computation of the expected final displacement of the block relative to the base. A necessary refinement

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is the consideration of amplification of the base motions in the embankment, which is evaluated by means of a linear elastic analysis. Sliding block analyses have been done for 348 horizontal components of natural earthquakes and 6 synthetic records. These computations, together with available results of amplification analyses, suggest that a pseudostatic seismic coefficient analysis would be appropriate for embankment dams where it is not necessary to consider (a) liquefaction or severe loss of shear strength, (b) vulnerability of the dam to small displacements, or (c) very severe earthquakes, of magnitude 8 or greater. A factor of safety greater than 1.0, with a seismic coefficient equal to one-half the predicted bedrock acceleration, would assure that deformations would not be dangerously large.

PREFACE

The screening analysis reported herein is based on seismic stability evaluations of several earth dams, in particular Richard B. Russell Dam in Georgia and South Carolina and Ririe Dam in Idaho, and was performed by the Earthquake Engineering and Geophysics Division (EE&GD), Geotechnical Laboratory (GL), U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss. This study was sponsored by the Office, Chief of Engineers (OCE), U. S. Army, under the Civil Works Investigational Studies (CWIS), Soils Research Program (Work Unit 31145), "Liquefaction of Dams and Foundations During Earthquakes," for which Mr. R. F. Davidson was the OCE Technical Monitor.

The research was conducted and the report prepared by Ms. M. E. Hynes-Griffin, EE&GD, and Dr. A. G. Franklin, Principal Investigator and Chief, EE&GD. Appendix A was prepared by Mr. F. K. Chang, EE&GD. The study was performed under the general supervision of Dr. W. F. Marcuson III, Chief, GL.

COL Tilford C. Creel, CE, was Commander and Director of WES during the preparation of this report. Mr. F. R. Brown was Technical Director.

CONTENTS

RATIONALIZING THE SEISMIC COEFFICIENT METHOD

PART I: INTRODUCTION

1. Until the 1960's, seismic analysis of dams consisted essentially of the seismic coefficient method, in which a static, horizontal inertia force was applied to the potential sliding mass in an otherwise conventional static limit analysis. The magnitude of the inertia force was chosen on the basis of judgment and tradition; a rational basis was lacking. Alternatives to this approach became available during the 1960's and 1970's. A method of analysis that dealt with the softening or liquefaction of granular soils was evolved, largely through work at the University of California at Berkeley, with Professor H. B. Seed playing the leading role. This approach is based on comparison of dynamic shear stresses computed in a transient response analysis to the cyclic strength (resistance to liquefaction) obtained from laboratory cyclic shear tests or from empirical correlations of liquefaction occurrence (and nonoccurrence) with Standard Penetration Tests (Seed, et al. 1975a, b; Seed 1979; Seed and Idriss 1983). A second alternative is to deal with the permanent deformations that might be anticipated if the embankment and foundation soils do not suffer liquefaction or severe softening under cyclic loading, using as an idealized model of the displaced part of the embankment a rigid block sliding on an inclined plane. This approach was proposed by the late Professor N. M. Newmark in his Rankine Lecture (1965). Other contributions to a coherent procedure using this approach have been made by Professors Ambraseys and Sarma, Imperial College, London (e.g. Ambraseys and Sarma 1967; Sarma 1975, 1979), the Berkeley group (Goodman and Seed 1966, Makdisi and Seed 1977), and the U. S. Army Engineer Waterways Experiment Station (WES) (Franklin and Chang 1977, Franklin and Hynes-Griffin 1981).

2. Sufficient experience has been gained in the application of the Newmark approach to allow some conclusions to be drawn. In the absence of liquefaction effects, dams with adequate static factors of safety against sliding are not likely to be predicted by this analysis to be subject to deformations so large as to endanger their reservoirs, through limited sliding deformations may be predicted. This result suggests that many--perhaps most--permanent displacement analyses do not really need to be done, and that some simple screening method should be applied to separate those dams that are clearly

safe against earthquake-induced failure from those that require further analysis. A seismic coefficient analysis can serve this screening function, because the accumulated experience in permanent displacement analyses now provides a rational basis for choosing the value of the coefficient. The rationale is based on assuring that deformations will be limited to tolerable values, assuming the worst combination of earthquake loads and resonant embankment response. A procedure that uses this approach is proposed in this report.

PART II: PERMANENT DISPLACEMENT ANALYSIS

3. The major components of a permanent displacement analysis of the Newmark type, as applied by the WES, are shown in Figure 1. The primary component is the analysis of motions of a system consisting of a rigid block sliding on an inclined plane, chosen to represent a potential sliding mass in an embankment, as described by Newmark. A conventional limit analysis, or slope stability analysis, with slight modifications, provides the shearing resistance between the block and plane. Because bedrock motions may be amplified upon being propagated upward through an embankment, a rigid-body model may underestimate displacements, and an analysis of the amplification response of the embankment is incorporated to account for amplified accelerations in the embankment.

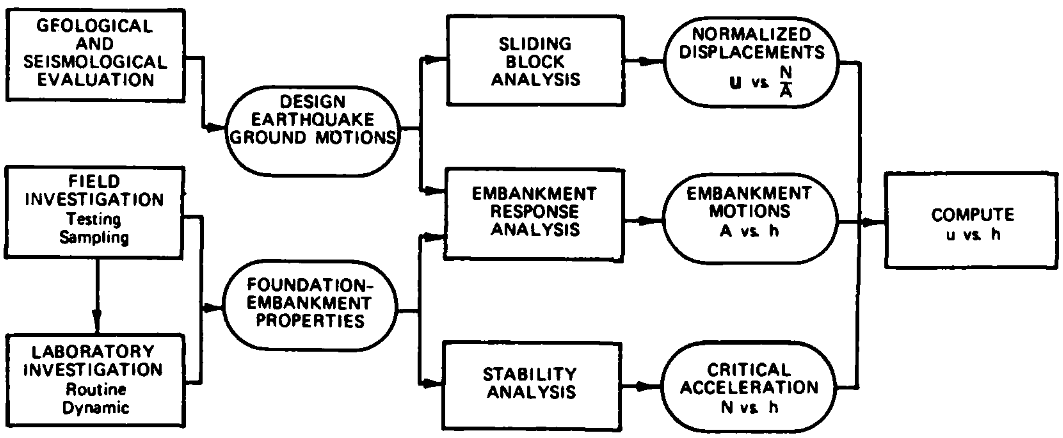
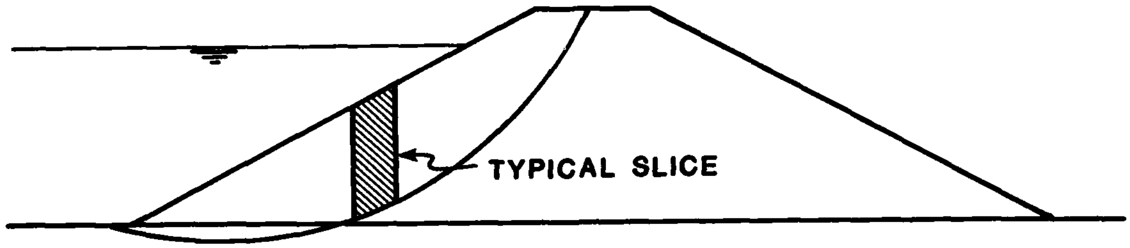


Figure 1. Permanent displacement analysis

<u>Stability Analysis</u>

4. The concept of the traditional pseudostatic, seismic coefficient method of analysis is illustrated in Figure 2. In an otherwise conventional static stability analysis, such as a method of slices analysis, the earthquake loading is represented by a statically applied horizontal force kW , where W is the weight of the slice and k is the seismic coefficient, which is some fraction of gravity. The value of k is generally prescribed by code or regulation, with values usually in the range of 0.05 to 0.20, depending on the seismicity of the site. The procedure is described in EM 1110-2-1902 (U. S. Army, Office, Chief of Engineers 1970) and in many standard texts.



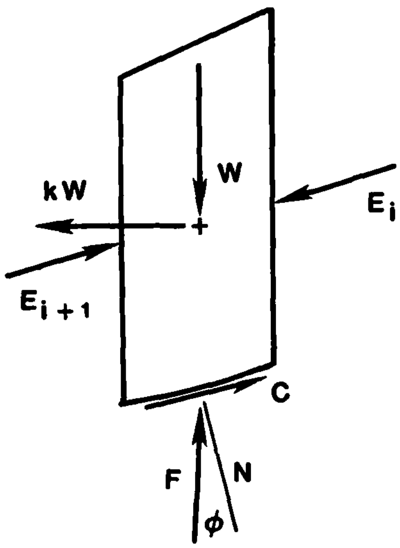


Figure 2. Earthquake stability analysis by pseudostatic method using seismic coefficient

5. For analysis of permanent displacements, the shearing resistance between the potential sliding mass and the underlying base is evaluated in terms of a critical acceleration N , defined as the acceleration (of the ground or embankment below the sliding surface) that will reduce the factor of safety against sliding to unity, i.e., that will make sliding imminent. The value of N , which is expressed as a fraction of gravity (g) , is obtained through a stability analysis similar to conventional pseudostatic stability analyses, but which includes two special features. One is that the stability is evaluated in terms of a critical acceleration rather that a factor of safety, and the other is that, because the amplified accelerations vary over the height of the embankment, critical accelerations are determined for possible sliding masses whose bases lie at various elevations in the section (Figure 3).

6. The analysis may be performed using conventional stability analysis

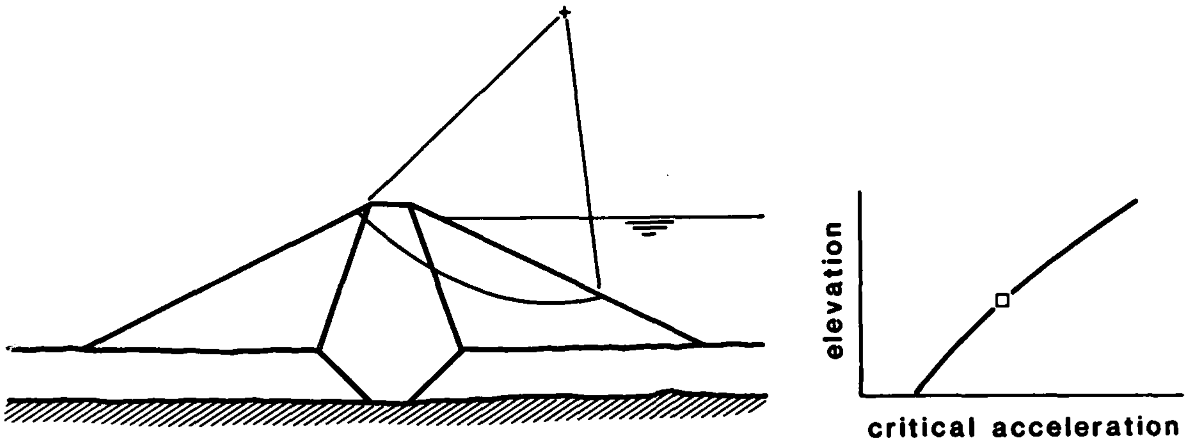


Figure 3. Critical acceleration as a function of elevation

methods such as those of Bishop (1955) or Morgenstern and Price (1965). Trial values of acceleration may be used to find the value that reduces the factor of safety to unity. The Sarma method (Sarma 1975), which employs a slip surface of arbitrary shape, determines the value of N directly.

7. In principle, the analysis can be performed on either a total or an effective stress basis, but the problems of estimating pore pressures induced by cyclic shearing are avoided by using a total stress analysis. The usual Corps of Engineers practice for static stability analyses is to use a composite shear strength envelope based on the S test (consolidated-drained) at low confining pressures and the R test (consolidated-undrained) at high confining pressures (Figure 4). This strength envelope, which conservatively takes into account possible dissipation of shear-induced negative pore pressures that might occur in the field but cannot occur in an undrained test in the laboratory, is recommended for pervious soils. For soils of low permeability, in which undrained conditions are more likely to exist during an earthquake, an undrained (R) strength envelope would be appropriate.

8. Makdisi and Seed (1977) point out that substantial permanent strains may be produced by cyclic loading of soils to stresses near the yield stress, while essentially elastic behavior is observed under many (>100) cycles of loading at 80 percent of the undrained strength. They recommend the use of 80 percent of the undrained strength as the "dynamic yield strength" for soils that exhibit small increases in pore pressure during cyclic loading, such as clayey materials, dry or partially saturated cohesionless soils, or very dense saturated cohesionless materials.

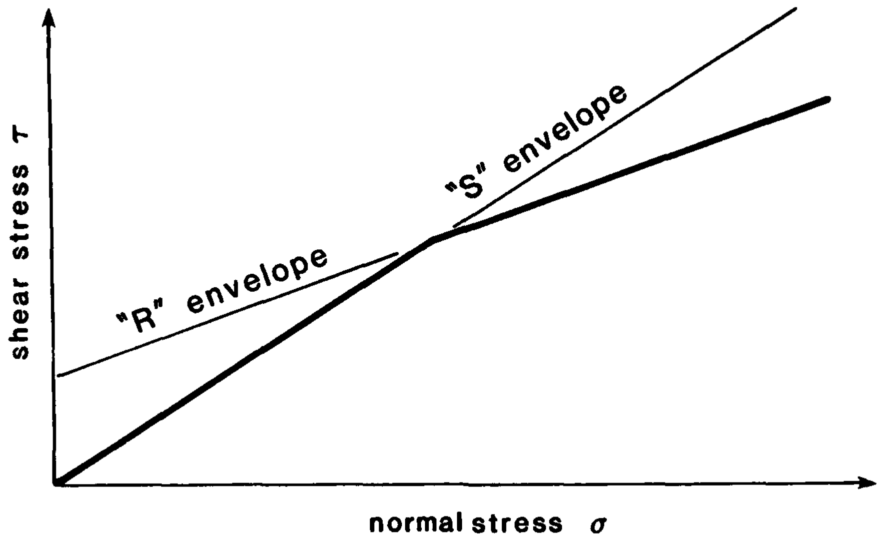


Figure 4. Composite "S-R" strength envelope

Sliding Block Analysis

9. Figure 5 presents the elements of the sliding block analysis (Franklin and Chang 1977). The potential sliding mass in Figure 5a is in a condition of impending failure, so that the factor of safety equals unity. This condition is caused by the acceleration of both the base and the mass toward the left of the sketch with an acceleration of Ng . The acceleration of the mass is limited to this value by the limit of the shear stresses that can be exerted across the contact, so that if the base acceleration were to increase, the mass would move downhill relative to the base. By D'Alembert's principle, the limiting acceleration is represented by an inertia force NW applied pseudostatically to the mass in a direction opposite to the acceleration.

10. Figure 5b shows the force polygon for this situation. The angle of inclination θ of the inertia force may be found as the angle that is most critical; this is, the angle that minimizes N . Its value is usually within a few degrees of zero, and since the results of the analysis are not sensitive to it, it can generally be ignored. The angle β is the direction of the resultant S of the shear stresses on the interface and is determined in the course of the stability analysis. The same force polygon applies to the model of a sliding block on a plane inclined at an angle β to the horizontal (Figure 5c). Hence, the sliding block model is used to represent the sliding mass in an embankment.

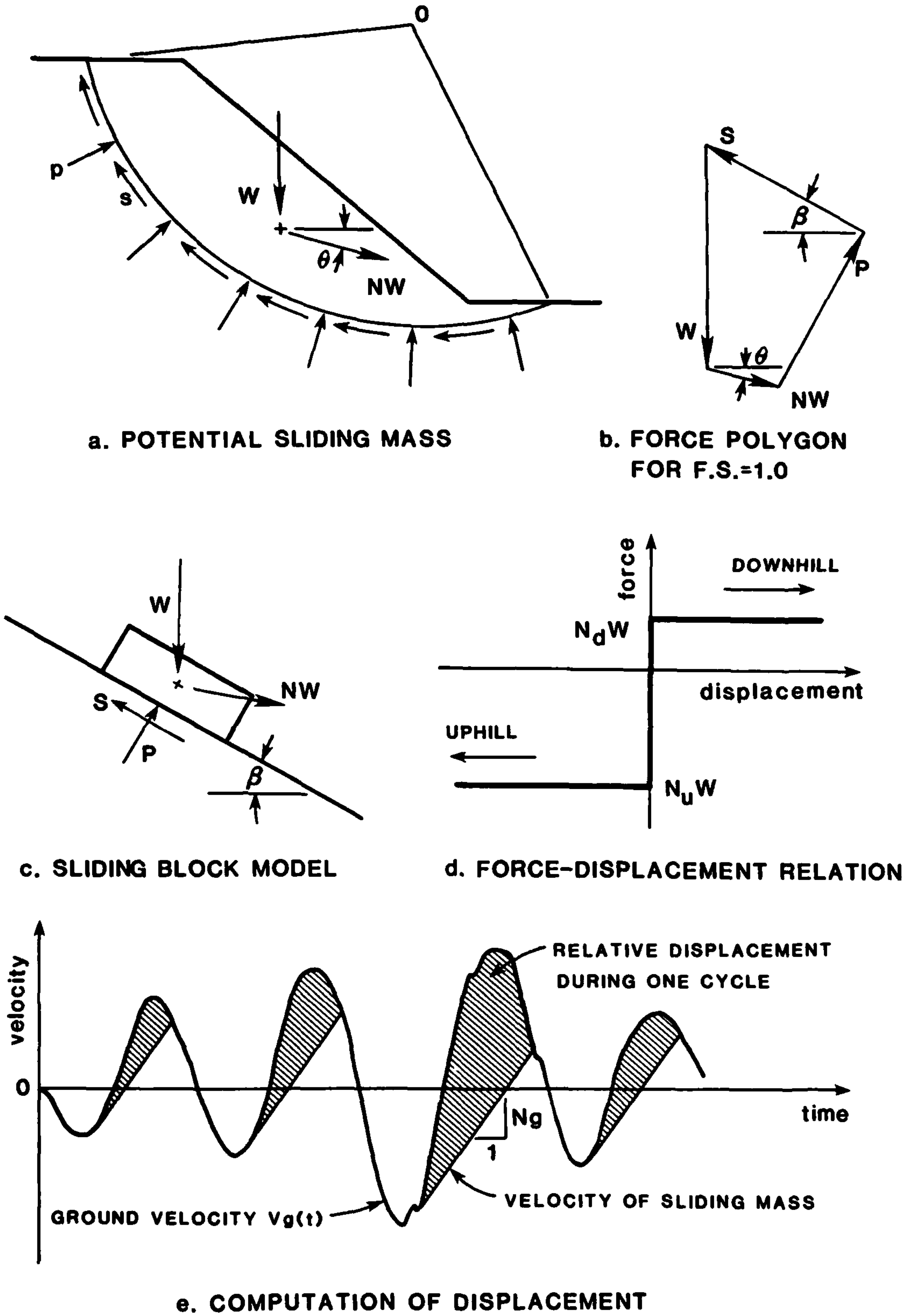


Figure 5. Elements of the sliding block analysis

11. The force-displacement relation in Figure 5d is assumed to apply to this system. The force in this diagram is the inertia force corresponding to the instantaneous acceleration of the block, and the displacement is the sliding displacement of the block relative to the base. It is usually assumed that resistance to uphill sliding is large enough that all displacements are downhill. This assumption, in addition to simplifying the calculations, is both realistic and conservative (Franklin and Chang 1977).

12. If the base (i.e., the inclined plane) is subjected to some sequence of acceleration pulses (the earthquake) large enough to induce sliding of the block, the result will be that after the motion has abated, the block will come to rest at some displaced position down the slope. The amount of permanent displacement, which will be called u, can be computed by using Newton's second law of motion, $F = ma$, to write the equation of motion for the sliding block relative to the base, and then numerically or graphically integrating (twice) to obtain the resultant displacement. During the time intervals when relative motion is occurring, the acceleration of the block relative to the base is given by

$$\ddot{u} = a_{rel} = \left(a_{base} - N\right) \cdot \frac{\cos\,(\beta - \theta - \phi)}{\cos\,\phi} \qquad (1)$$

$$= \left(a_{base} - N\right) \cdot \alpha$$

where

a_{rel} = relative acceleration between the block and the inclined plane

a_{base} = acceleration of the inclined plane, a function of time

N = critical acceleration level at which sliding begins

β = direction of the resultant shear force and displacement, and the inclination of the plane

θ = direction of the acceleration, measured from the horizontal

ϕ = friction angle between the block and the plane

The acceleration a_{base} is the earthquake acceleration acting at the level of the sliding mass in the embankment. It is assumed to be equal to the bedrock acceleration multiplied by an amplification factor that accounts for the quasi-elastic response of the embankment.

13. The permanent displacement is determined by twice integrating the relative accelerations over the total duration of the earthquake record. It is assumed that ϕ , β , and θ do not change with time; thus, the coefficient

α is a constant and is not involved in the integration. In the final stage of analysis, the result of the integration is multiplied by the coefficient α, the determination of which requires knowledge of the embankment properties and the results of the pseudostatic stability analysis. For most practical problems, the coefficient α differs from unity by less than 15 percent (Figure 6). For the purposes of this report, a value of unity will be assumed.

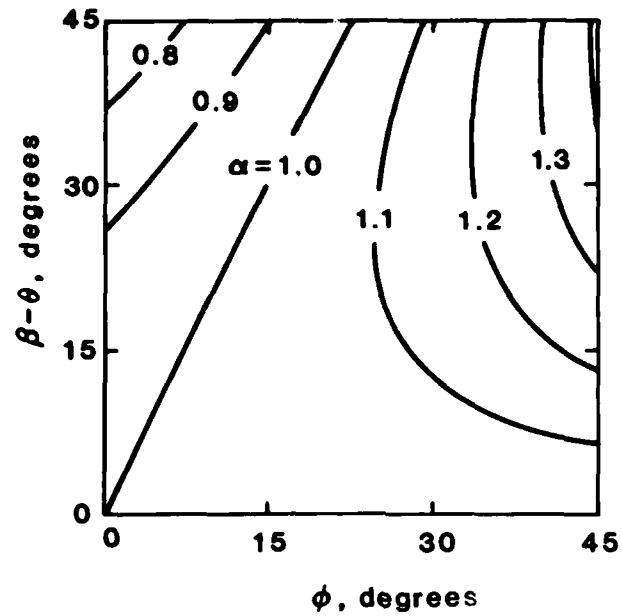


Figure 6. Values of the coefficient α

14. The integration can be easily visualized on a plot of base velocity versus time, obtained by a single integration of the acceleration record (Figure 5e). Since the slope of the velocity curve is the acceleration, the limiting acceleration Ng of the block defines the velocity curve for the block by straight lines in those parts of the plot where the critical acceleration has been exceeded in the base. The area between the curves gives the relative displacement.

15. In this analysis, the characteristics of the sliding mass in the embankment are represented only by the critical acceleration N and the amplification factor, the latter being simply a constant multiplying factor. The permanent displacement u for a particular earthquake record can be determined as a function of N/A, where Ag is the peak value of the earthquake acceleration, and the u versus N/A curve can be determined from the earthquake record without reference to a particular embankment.

16. Kutter (1982) has done limited experimental testing of this method by means of model embankments shaken by simulated earthquakes in the Cambridge University geotechnical centrifuge. For these tests, the sliding block model gave poor predictions of very small displacements (<1 cm), but if strength degradation was provided for, it produced good predictions when the displacements at prototype scale were greater than about 1 cm.

17. The following example, drawn from Kutter's test results for embankment model D and earthquake I, demonstrates the application of the displacement calculation procedures described herein. If the yield acceleration for the embankment model is calculated on the basis of 80 percent of the measured shear strength, and the measured amplification of the base motion is included, the predicted displacement is 15.0 cm and the corresponding measured displacement is 16.4 cm at the prototype scale.

18. Sliding block analyses have been done at the WES for 348 horizontal earthquake components and 6 synthetic records. These calculations are tabulated in Appendix A. The results are summarized in Figure 7, which shows the mean, mean plus one standard deviation (σ), and upper bound curves, for all natural records and all synthetic records representing magnitudes smaller than 8.0. (Caution is recommended in interpreting these curves quantitatively in terms of relative probability, because the data base is biased by overrepresentation of a single earthquake, the 1971 San Fernando earthquake, which produced records at many locations.)

19. The question of how much deformation is tolerable has no single answer; it depends on such factors as the size and geometry of the dam, the zonation, the location of the sliding surface, and the amount of freeboard available. The authors have arbitratily chosen 1 m of permanent displacement as a tolerable upper limit. Such a deformation would surely be considered serious damage, but it could be tolerated in most dams without immediately threatening the integrity of the reservoir. The unusual cases where a dam could not tolerate 1 m of displacement, because of small freeboard or vulnerability of critical design features to small displacements, should be evaluated by other methods.

20. When Figure 7 is entered at 100 cm (1 m) of displacement, the corresponding N/A value is 0.17. Thus, deformations will be limited to less than 1 m of displacement if the critical acceleration is as much as 0.17 times the peak acceleration on the sliding surface.

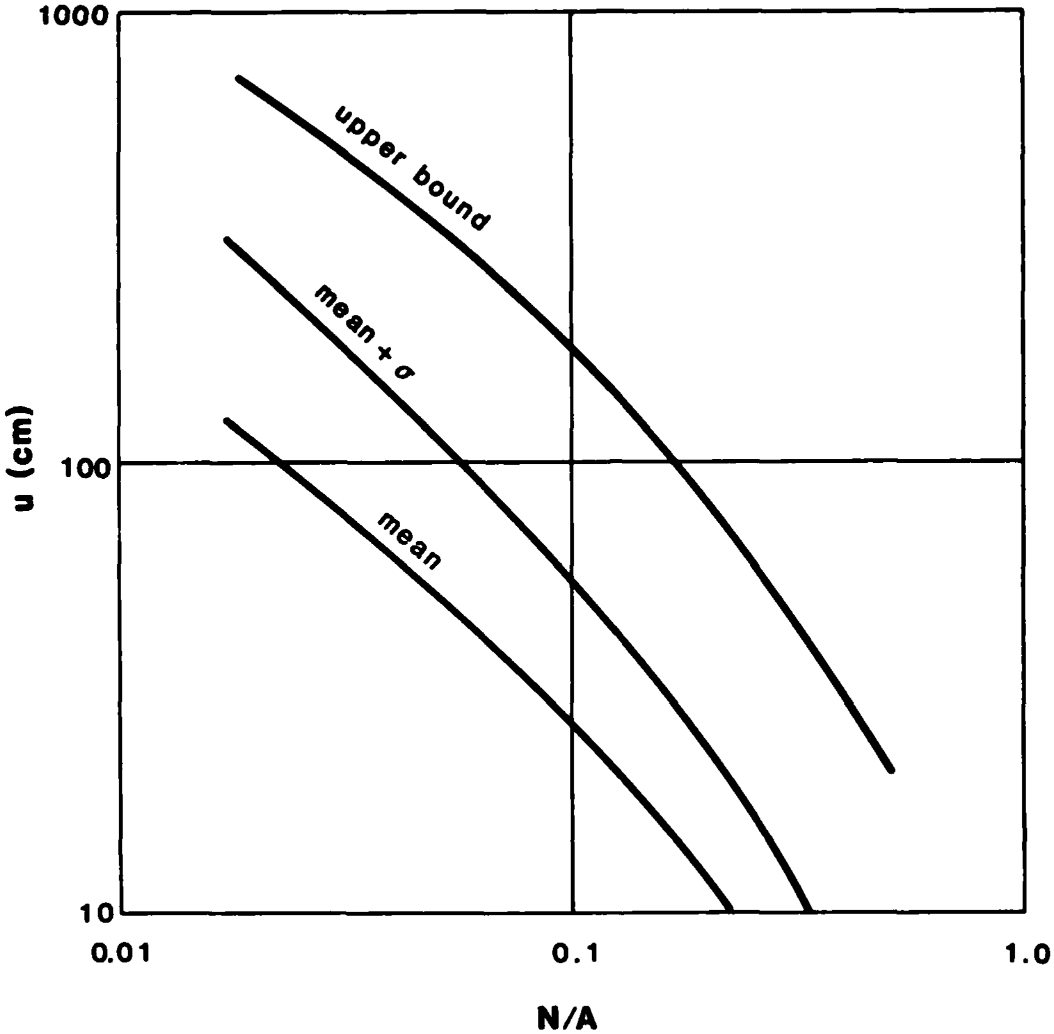


Figure 7. Permanent displacement u versus N/A , based on 348 horizontal components and 6 synthetic accelerograms

Embankment Response Analysis

21. Amplification of ground motions in the embankments may be examined by analysis of a shear-beam model of the embankment-foundation system. A closed-form solution has been obtained by Sarma (1979) for the problem illustrated by Figure 8. The model considered is an untruncated triangular wedge of height h_1 with a shear-wave velocity S_1 and density ρ_1 , underlain by a foundation layer with thickness h_2 , shear-wave velocity S_2 , and density ρ_2 . Both the wedge and foundation are linearly visco-elastic and have the same damping ratio D . The earthquake motions are considered to be rigid-body

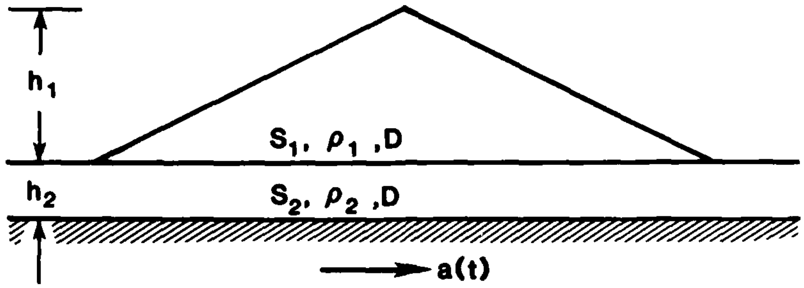


Figure 8. Mathematical model for viscoelastic shear beam analysis of embankment and foundation response by the Sarma method

motions in the rock underlying the foundation layer, and it is assumed that all motions are horizontal (hence, a shear-beam model). Shear-wave velocities and damping values are chosen so as to be consistent with expected strain levels. The computation of accelerations is carried out in the time domain.

22. Geometry and material properties are described in terms of the dimensionless parameters m and q, which are defined as

$$m = \frac{\rho_1 S_1}{\rho_2 S_2} \quad \text{and} \quad q = \frac{S_1 h_2}{S_2 h_1} \tag{2}$$

23. For use with the sliding block analysis, accelerations are averaged over a wedge that is selected to be approximately equivalent in volume and location to a potential sliding mass with its base at some chosen elevation, as shown in Figure 9. The average acceleration acting on the wedge at any instant is taken as

$$a_{av} = \frac{\int_A a(z)\ dA}{A} \tag{3}$$

where $a(z)$ is the acceleration of the area element dA, at elevation z, and A is the total area of the wedge.

24. The largest average acceleration that acts on the wedge at any time during the earthquake shaking is produced as the output of the computer program, and the ratio of that acceleration value to the peak bedrock acceleration is taken as the amplification factor for the wedge. In Figure 10, values of the amplification factor are plotted against the embankment fundamental period T_o for one record of the Parkfield earthquake of 27 June 1966. Curves

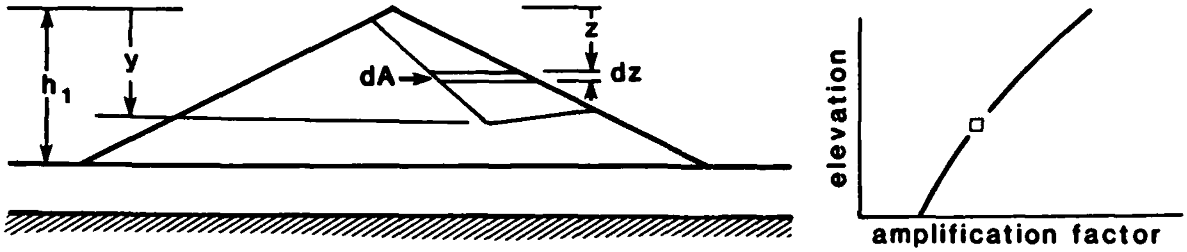


Figure 9. Computation of average acceleration acting on the sliding mass

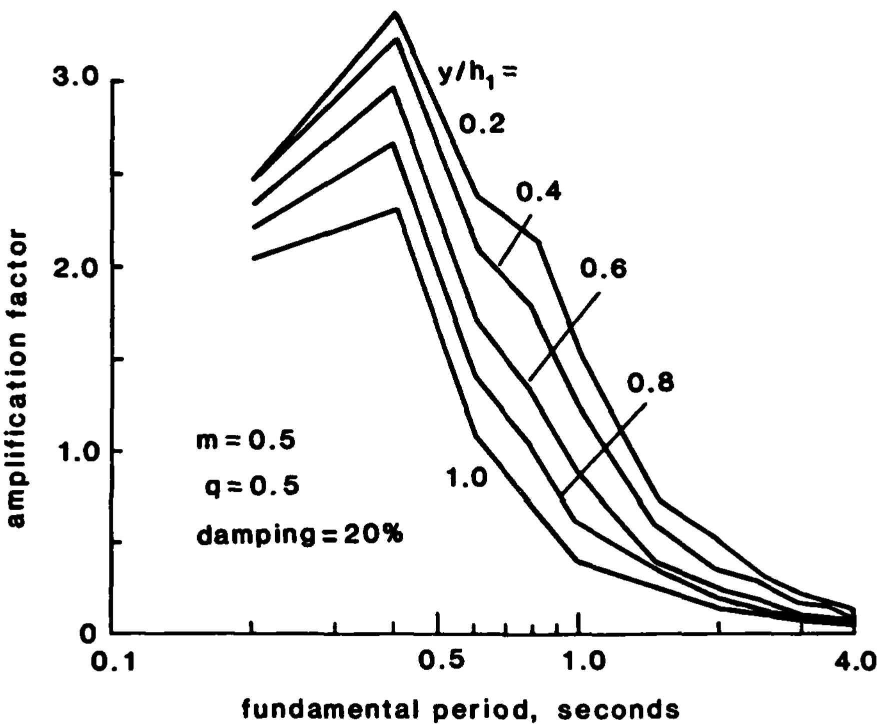


Figure 10. Amplification curves for the S 25 W component, Temblor No. 2 Record, Parkfield earthquake of 27 June 1966 (damping = 20 percent)

are shown for wedges with their bases at various distances y/h_1 (defined in Figure 9) from the crest, for a single combination of m and q values (m = 0.5, q = 0.5).

25. Amplification curves have been obtained from 27 strong-motion earthquake records and a wide range of m and q values (representing embankments on rock and on foundation layers of varied thickness, and with a variety of relative embankment-foundation stiffnesses). Damping values used ranged from 15 to 20 percent. Also, numerous computed amplification values have been obtained from finite element analyses and from the literature.

Figure 11 presents a summary of computed resonant response, obtained by plotting the values at the peaks of the amplification curves. Table 1 shows these peak amplification values. Amplification values obtained from finite element analyses, which do not necessarily represent resonant conditions, are generally lower than these curves indicate.

26. To use these curves in a permanent displacement analysis, pick off the amplification factor for the depth of sliding being investigated, and multiply the peak bedrock acceleration by that value before entering the plot of displacement versus N/A . This step involves an assumption that the sliding block analysis and the amplification analysis can be decoupled. In fact, there is good reason to believe that decoupling results in overestimates of the amplification when very strong shaking is involved. The amplification may be large in cases where the motions are small and the embankment behavior is nearly elastic (Gazetas, et al. 1981), but this assumption is not compatible with inelastic embankment response. If accelerations are high enough to produce sliding on a deep surface, then the embankment is incapable of propagating these large accelerations to higher elevations. The critical acceleration on a slip surface defines the magnitude of acceleration that can be propagated beyond it. At the same time, the critical acceleration always decreases with depth, in a homogeneous section with constant slopes.

27. A note of caution is in order for dams with abrupt changes in section or zoning that would cause a reduction in yield accelerations for slip surfaces above the base of the embankment. For example, some dams have slopes that steepen abruptly near the crest. However, for upstream slip surfaces, the reduction in yield acceleration due to steeper slopes is usually more than offset by an increase due to lower pore pressures if the steeper section lies above the pool elevation. Upstream or downstream berms will also result in relatively reduced yield accelerations for slip surfaces that lie entirely above the berms. For these or similar cases, a profile of yield accelerations can be developed from stability analyses; Figure 11 can be used to estimate amplification factors; and potential displacement can be calculated from Figure 7 for each of the potential slip surfaces identified in the stability analyses.

28. The authors conclude that, except for a few special cases, deep sliding surfaces are of greatest significance when evaluating the possibility of displacements that could threaten the integrity of the structure, and

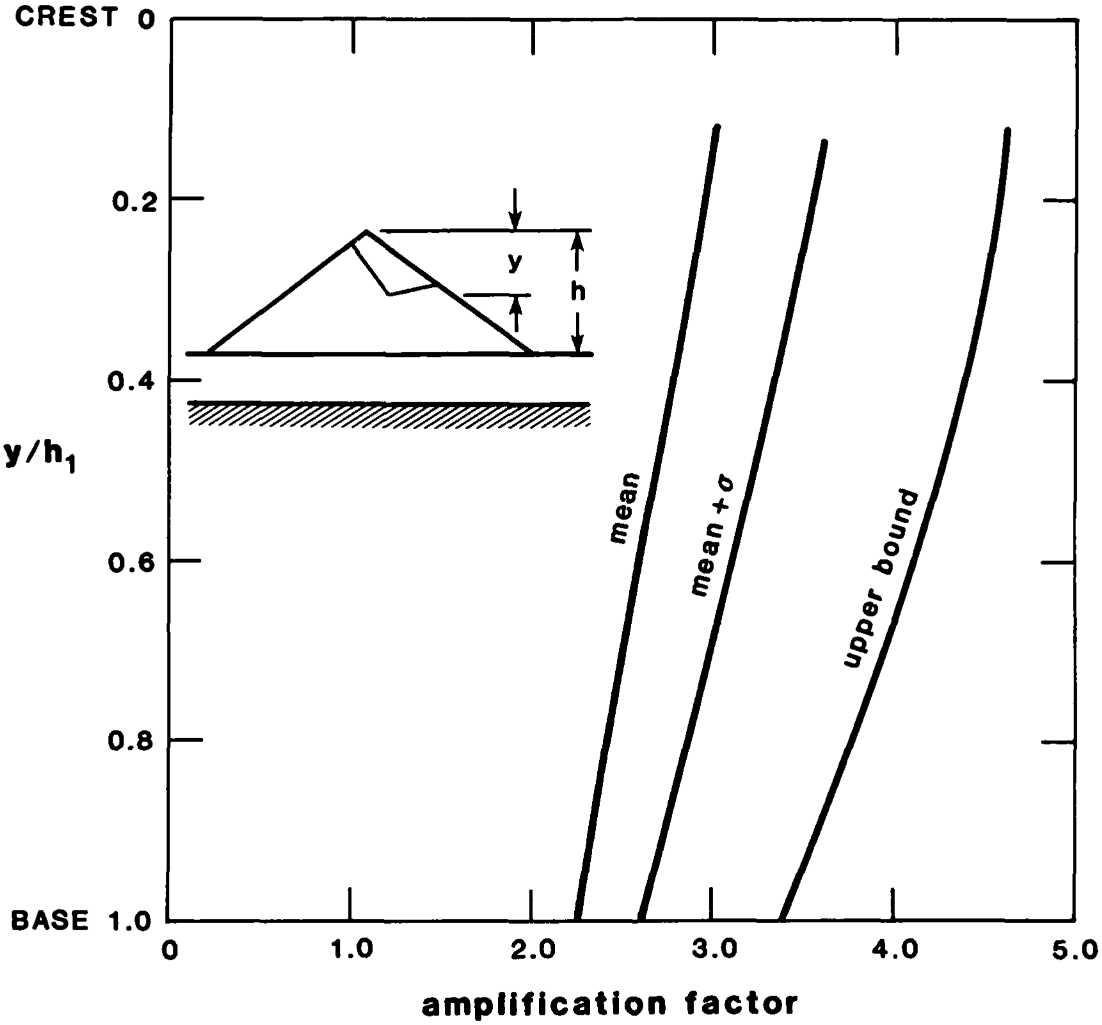


Figure 11. Amplification factors for linearly viscoelastic embankments at resonance

accordingly, they look for a limiting amplification factor representing sliding surfaces at the base of the embankment. Figure 11 shows that the value at the mean plus 2σ limit is approximately 3.0. Applying this amplification factor to the N/A value, 0.17, which gives an upper bound of 1-m displacement for the rigid-plastic sliding block, the ratio of critical acceleration to peak bedrock acceleration is 0.5.

PART III: CONCLUSIONS

29. The results of analysis of earthquake strong-motion records using a sliding block model and a decoupled elastic response analysis show that permanent displacements for deep-seated sliding surfaces limited to less than 1 m can be assured if the ratio of critical acceleration to peak bedrock acceleration is at least 0.5. This value is considered to be very conservative and subject to downward revision as better understanding of elastic-plastic amplification response of embankments is developed.

30. Furthermore, a pseudostatic, seismic coefficient analysis can serve as a useful screening procedure to separate dams that are clearly safe against earthquake-induced sliding failure from those that require further analysis. The permanent displacement analyses described in this report provide a rational basis for choosing the value of the seismic coefficient.

31. The suggested procedure is as follows:

- a. Carry out a conventional pseudostatic stability analysis, using a seismic coefficient equal to one-half the predicted peak bedrock acceleration.
- b. Use a composite S-R strength envelope for pervious soils, and the R (undrained) strength for clays, multiplying the shear strength in either case by 0.8.
- c. Use a minimum factor of safety of 1.0.

32. This procedure should not be used in the following cases:

- a. Where areas are subject to great earthquakes (of magnitude 8.0 or greater).
- b. Where materials in either the embankment or foundation are susceptible to liquefaction under the design cyclic loading.
- c. Where the available freeboard is small, or where the dam has safety-related features that are vulnerable to small deformations.

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Table 1

Amplification Factors for Embankment Response at Resonance Amplification Factor

		$\frac{y}{h_1}$					$\frac{y - h_1 + h_2}{h_2}$						
m	q	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	Damping Percent	Accelerogram
0	0	2.68	2.50	2.31	2.06	1.77	--					20	
0.5	0.125	2.89	2.58	2.41	2.18	1.63	1.56	--					
0.5	0.25	3.34	2.92	2.55	2.35	2.10	1.64	1.56	1.44	--			
0.5	0.375	3.50	3.16	2.77	2.54	2.29	2.03	1.80	1.61	1.49	--		Maximum of 9 records:
0.5	0.5	3.47	3.20	2.88	2.66	2.44	2.20	1.99	1.80	1.61	1.51		a. San Fernando 1971, Pacoima, 3 components
0.5	0.75	3.15	2.98	2.81	2.65	2.51	2.33	2.17	2.03	1.92	1.79		
0.5	1.00	2.78	2.71	2.64	2.57	2.49	2.37	2.26	2.15	2.07	1.98		b. El Centro 1940, 2 components
1.00	0.25	2.66	2.55	2.43	2.26	2.07	1.85	1.78	--				c. Koyna 1967, 2 components
1.00	0.50	2.54	2.49	2.41	2.32	2.17	2.02	1.85	1.75	--			d. Parkfield 1966, Cholame, 1 component
1.00	0.75	2.46	2.44	2.39	2.32	2.22	2.11	1.98	1.84	1.71	--		e. Port Hueneme 1957, 1 component
1.00	1.00	2.42	2.40	2.36	2.31	2.23	2.15	2.06	1.94	1.83	1.70		
1.00	1.50	2.37	2.36	2.33	2.31	2.26	2.20	2.14	2.07	1.99	1.92		
1.00	2.00	2.36	2.35	2.33	2.30	2.27	2.24	2.19	2.13	2.08	2.03		
0.8	0.8	2.57	2.53	2.47	2.40	2.30	2.18	2.07	1.93	1.79	1.66		
0	0	2.58	2.29	1.89	1.66	1.43	--						Helena 1935, Carroll College, E-W
0.5	0.185	3.16	2.65	2.19	1.82	1.62	--						Helena 1935, Carroll College, E-W
0.5	0.5	2.98	2.77	2.41	2.23	1.95	--						Helena 1935, Carroll College, E-W
0	0	2.98	2.70	2.62	1.91	1.57	--						Parkfield 1966, Temblor No. 2, S 25 W
0.5	0.185	3.34	3.04	2.58	2.19	1.79	--						Parkfield 1966, Temblor No. 2, S 25 W
0.5	0.5	3.38	3.23	2.97	2.66	2.31	--						Parkfield 1966, Temblor No. 2, S 25 W
0	0	2.55	2.44	2.25	2.01	1.71	--						Oroville 1975, Oroville Dam, N 53 W
0.5	0.185	2.68	2.56	2.41	2.20	1.95	--						Oroville 1975, Oroville Dam, N 53 W
0.5	0.5	2.69	2.67	2.61	2.51	2.35	--						Oroville 1975, Oroville Dam, N 53 W
0	0	2.31	2.04	1.96	1.82	1.63	--						San Fernando 1971, Griffith Park, N-W
0.5	0.185	2.66	2.31	2.07	1.95	1.78	--						San Fernando 1971, Griffith Park, N-W
0.5	0.5	2.61	2.44	--	--	--							San Fernando 1971, Griffith Park, N-W

(Continued)

Table 1 (Continued)

		$\frac{y}{h_1}$					$\frac{y - h_1 + h_2}{h_2}$						
m	q	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	Damping Percent	Accelerogram
0	0	2.01	1.90	1.73	1.54	1.31	--					20	San Fernando 1971, Castaic N 69 W
0.5	0.185	2.26	2.13	1.88	1.68	1.48	--						San Fernando 1971, Castaic N 69 W
0.5	0.5	2.47	2.38	2.24	2.02	1.82	--						San Fernando 1971, Castaic N 69 W
0	0	2.19	1.96	--									San Fernando 1971, Castaic N 21 E
0.5	0.185	2.57	2.22	--									San Fernando 1971, Castaic N 21 E
0.5	0.5	2.09	2.52	2.26	--								San Fernando 1971, Castaic N 21 E
0.5	0.5	4.36	4.02	3.61	3.19	2.73	2.21	1.84	1.65	1.53	1.44	15	El Centro Array No. 10, Keystone Road, N 50 E, 10/15/79
1.00	0.5	3.43	3.26	3.03	2.78	2.50	2.15	1.97	1.79	1.73	1.67		El Centro Array No. 10, Keystone Road, N 50 E, 10/15/79
0.5	0.5	3.30	3.14	2.85	2.55	2.39	2.16	1.97	1.84	1.75	1.66		Imperial Valley Earthquake, Holtville Post Office, S 45 W, 10/15/79
1.0	0.5	2.70	2.60	2.54	2.44	2.30	2.13	2.02	1.91	1.85	1.78		Imperial Valley Earthquake, Holtville Post Office, S 45 W, 10/15/79
0.5	0.5	4.58	4.40	4.12	3.78	3.38	2.91	2.44	2.17	1.99	1.85		Imperial Valley Earthquake, Holtville Post Office, N 45 W, 10/15/79
1.0	0.5	3.92	3.81	3.63	3.41	3.15	2.86	2.67	2.47	2.38	2.29		Imperial Valley Earthquake, Holtville Post Office, N 45 W, 10/15/79
0.5	0.5	4.01	3.81	3.49	3.08	2.64	2.19	1.79	1.60	1.50	1.39		Western Washington Earthquake, U. S. Army Base STA 0000, S 02 W, 4/13/49
1.0	0.5	3.24	3.08	2.85	2.59	2.38	2.14	1.99	1.83	1.76	1.68		Western Washington Earthquake, U. S. Army Base STA 0000, S 02 W, 4/13/49
0.5	0.5	3.95	3.75	3.44	3.09	2.72	2.26	1.83	1.60	1.51	1.44		Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 40 E, 10/15/79
1.0	0.5	3.25	3.14	2.97	2.75	2.50	2.22	2.05	1.87	1.79	1.71		Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 40 E, 10/15/79
0.5	0.5	3.32	3.21	3.02	2.78	2.49	2.14	1.84	1.65	1.53	1.43		Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 50 W, 10/15/79
1.0	0.5	2.78	2.71	2.62	2.48	2.30	2.09	1.98	1.86	1.81	1.75		Imperial Valley Earthquake, El Centro Array No. 3, Pine Union School, S 50 W, 10/15/79
0.5	0.5	3.13	2.93	2.63	2.35	2.09	1.80	1.53	1.40	1.32	1.25		El Centro Array No. 10, Keystone Road, N 40 W, 10/15/79
1.0	0.5	2.41	2.35	2.24	2.11	1.95	1.77	1.66	1.54	1.50	1.46		El Centro Array No. 10, Keystone Road, N 40 W, 10/15/79

(Continued)

Table 1 (Concluded)

	$\frac{y}{h_1}$					$\frac{y - h_1 + h_2}{h_2}$				
	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
Summary Values of Amplification Factors										
Average	2.95	2.77	2.61	2.40	2.17	2.14	1.98	1.83	1.76	1.69
(σ)	(0.58)	(0.54)	(0.50)	(0.46)	(0.44)	(0.29)	(0.25)	(0.25)	(0.25)	(0.25)
Average + σ	3.53	3.31	3.11	2.86	2.61	2.43	2.23	2.08	2.01	1.94
Maximum	4.58	4.40	4.12	3.78	3.38	2.91	2.67	2.47	2.38	2.29

(Sheet 3 of 3)

APPENDIX A

TABLES OF SLIDING BLOCK CALCULATIONS FOR STRONG-MOTION DATA FROM EARTHQUAKES OF THE WESTERN UNITED STATES AND OTHER COUNTRIES, AND SYNTHETIC ACCELEROGRAMS

Table A1

Strong-Motion Data, Earthquakes of Western United States (Uniformly Processed at California Institute of Technology), and Other Countries

CIT File No.	Recording Station	Site Classification*	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
A001	El Centro Site, Imperial Valley	A	5-18-40	32°44' N	S 00° E	341.7	33.4	10.9	9.3	6.7	VIII	30	161.3	(190.7)†	38.85	(53.87)†	1.34	(0.59)†
				115°27' W	S 90° W	210.1	36.9	19.8				53	191.8	(211.9)	57.68	(49.9)	1.88	(1.23)
					Up	206.3	10.8	5.6										
A002	Northwest California Earthquake, Ferndale City Hall	I	10-7-51	40°17' N	S 44° W	102.0	4.8	2.4	56.3		V							
				124°48' W	N 46° W	109.5	7.4	2.7										
					Up	26.4	2.2	1.6										
A003	Kern County Earthquake, Athenaeum	A	7-21-52	35°00' N	S 00° E	46.5	6.2	2.7	126.0	7.7	VII	50		(80.35)		(27.03)		(0.94)
				119°02' W	S 90° W	52.1	9.1	2.9				50	84.08	(131.13)	34.17	(43.71)	1.51	(2.57)
					Up	29.3	4.5	3.0										
A004	Kern County Earthquake, Taft Lincoln School	A	7-21-52	35°00' N	N 21° E	152.7	15.7	6.7	43.0	7.7	VII	54	92.82	(101.2)	29.54	(23.73)	0.73	(0.84)
				119°02' W	S 69° E	175.9	17.7	9.2				54	112.2	(138.9)	28.50	(36.16)	0.91	(1.23)
					Up	102.9	6.7	5.0										
A005	Kern County Earthquake, Santa Barbara Courthouse	A	7-21-52	35°00' N	N 42° E	87.8	11.8	4.6	89.5	7.7	VII	54	124.33	(148.1)	46.15	(51.22)	1.05	(3.71)
				119°02' W	S 48° E	128.6	19.3	5.8				60	119.6	(196.4)	43.45	(46.34)	2.23	(0.00)
					Up	43.6	5.0	2.2										
A006	Kern County Earthquake, Hollywood Storage Basement	A	7-21-52	35°00' N	S 00° W	54.1	6.1	5.1	119.5	7.7	VII	82	68.71	(95.26)	22.15	(30.13)	0.58	(0.53)
				119°02' W	N 90° E	43.5	9.4	5.9				82	93.24	(150.11)	39.41	(50.78)	1.14	(1.16)
					Up	22.5	4.2	2.2										
A007	Kern County Earthquake, Hollywood Storage P E Lot	A	7-21-52	35°00' N	S 00° W	58.1	6.6	4.5	119.5	7.7	VII	79	79.10	(108.11)	23.39	(31.26)	0.405	(0.61)
				119°02' W	N 90° E	41.2	8.9	6.4				79	94.98	(160.15)	42.30	(55.75)	1.67	(1.44)
					Up	20.3	3.0	3.4										
A008	Eureka Earthquake, Eureka Federal Building	I	12-21-54	32°38' N	N 11° W	164.5	31.6	12.4	24.0	6.5	VII	26(36)	205.17	(141.44)	40.67	(29.74)	2.19	(0.55)
				117°07' W	N 79° E	252.7	29.4	14.1				30	105.01	(120.06)	30.10	(34.55)	1.98	(1.74)
					Up	81.3	8.2	4.7										
A009	Eureka Earthquake, Ferndale City Hall	I	12-21-54	32°38' N	N 44° E	155.7	35.6	14.2	40.4	6.5	VII	20(31)	292.22	(280.82)	91.98	(86.28)	9.04	(4.88)
				117°07' W	N 46° W	197.3	26.0	9.6				20(30)	137.05	(96.62)	38.37	(28.09)	2.36	(0.48)
					Up	41.9	7.6	3.9										
A010	San Jose Earthquake, San Jose Bank of America Basement	A	9-4-55	37°22' N	N 31° W	100.2	10.8	2.8	9.8	5.5	VII	30	17.58	(30.50)	4.54	(4.66)	0.35	(0.24)
				121°53' W	N 59° E	105.8	4.4	1.7				30		(12.31)		(2.40)		(0.14)
					Up	44.2	1.2	1.2										
A011	El Alamo, Baja California Earthquake, El Centro Site, Imperial Valley Irrigation District	A	2-9-56	31°45' N	S 00° W	32.4	4.0	2.4	125.9	6.8	VI	70		(76.25)		(26.27)		(0.89)
				115°55' W	S 90° W	50.1	7.0	4.1				70	89.58	(100.74)	30.51	(30.22)	0.61	(6.56)
					Up	12.4	2.9	1.6										
A012	El Alamo, Baja California Earthquake, El Centro Site, Imperial Valley Irrigation District (Aftershock)		2-9-56	31°45' N	S 00° W	11.8	1.9	1.7	125.9									
				115°55' W	S 90° W	15.4	2.7	2.3										
					Up	3.7	1.8	2.9										
A013	San Francisco Earthquake, San Francisco Pacific	I	3-22-57	37°40' N	N 45° S	45.9	2.9	1.1	16.8	5.3	VII	26		(12.93)		(3.99)		(0.08)
				122°29' W	N 45° W	44.9	5.0	1.4				26	27.17	(31.51)	8.80	(10.41)	0.24	(0.72)
					Up	26.8	1.5	0.9										
A014	San Francisco Earthquake, San Francisco Alexander Building Basement	I	3-22-57	37°40' N	N 09° W	41.8	2.9	1.3	15.2	5.3	VII	25	4.93	(4.95)	1.45	(1.35)	0.11	(0.05)
				122°29' W	N 81° E	45.4	2.1	1.0										
					Up	30.0	1.3	0.4										
A015	San Francisco Earthquake, San Francisco Golden Gate Park	I	3-22-57	37°40' N	N 10° E	81.8	4.9	2.3	11.8	5.3	VII	12	7.89	(2.76)	1.49	(0.82)	0.06	(0.09)
				122°29' W	S 80° E	102.8	4.6	0.8										
					Up	37.2	1.2	0.7										
A016	San Francisco Earthquake, San Francisco State Building Basement	I	3-22-57	37°40' N	S 09° W	83.8	5.1	1.1	14.6	5.3	VII							
				122°29' W	S 81° W	55.1	4.0	0.9										
					Up	43.5	2.3	0.6										
A017	San Francisco Earthquake, Oakland City Hall Basement	I	3-22-57	37°40' N	N 26° E	39.0	2.0	1.5	24.3	5.3	VI							
				122°29' W	S 64° E	23.7	1.2	1.1										
					Up	15.3	0.9	1.3										

(Continued)

Note: Locations in California unless otherwise noted.
* A = alluvium, I = intermediate, and HR = hard rock.
† Values in parentheses are for reversed direction of shaking.

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
A018	Holister Earthquake, Holister City Hall	A	4-8-61	36°40' N 121°18' W	S 01° W N 89° W Up	63.4 175.7 49.1	7.8 17.1 4.7	2.8 8.8 2.2	40.0	5.6	VII	30	58.58	(85.54)	12.98	(19.14)	0.23	(0.89)
A019	Borrego Mt Earthquake, El Centro Site, Imperial Valley Irrigation District	A	4-8-68	33°09' N 116°08' W	S 00° W S 90° W Up	127.8 56.3 29.7	25.8 14.7 3.4	12.2 11.0 3.9	69.8	6.5	VI	60	169.27	(306.78)	43.75	(53.13)	0.99	(1.46)
A020	Borrego Mt Earthquake, San Diego Light & Power Building	A	4-8-68	33°09' N 116°08' W	S 00° W N 90° E Up	29.5 28.9 12.7	6.0 6.1 1.9	4.4 3.0 1.3	109.9	6.5	VI	30						
B021	Long Beach Earthquake, Vernon CMD Building	A	3-10-33	33°35' N 117°59' W	N 08° E S 82° E Up	130.6 151.5 149.5	28.7 17.0 12.0	15.5 17.5 7.4	47.8	6.3	VI	30 30	156.41	(216.33) (66.0)	30.27	(37.21) (11.45)	0.88	(0.50) (0.17)
B022	Southern California Earthquake, Hollywood Storage Building Penthouse	A	10-2-33	33°47' N 118°08' W	S 00° E S 90° W Up	43.3 85.4 26.8	5.2 9.4 1.9	1.8 4.3 0.9	38.2	5.4	V							
B023	Southern California Earthquake, Hollywood Storage Building Basement '	A	10-2-33	33°47' N 118°08' W	S 00° E S 90° E Up	32.1 26.4 10.7	2.0 2.2 0.9	0.8 0.4 0.5	38.2	5.4	V							
B024	Lower California Earthquake, El Centro Imperial Valley	A	12-30-34	32°12' N 115°30' W	N 00° E N 90° E Up	156.8 179.1 68.1	20.5 11.5 8.8	4.2 3.7 5.6	60.8	6.5	VI	30 30	89.64	(81.21) (95.92)	24.96	(25.19) (28.65)	0.31	(0.67) (1.17)
B025	Helena, Montana Earthquake, Helena, Montana, Carroll College	NR	10-31-35	46°37' N 111°58' W	N 00° E N 90° E Up	143.5 142.5 87.5	7.3 13.3 9.5	1.4 3.7 2.8	6.6	6.0	VII	5 5	25.07	(11.40) (23.59)	6.33	(3.00) (6.83)	0.29	(0.06) (0.58)
B026	1st Northwest California Earthquake, Ferndale City Hall	I	9-11-38	40°18' N 124°48' W	S 45° W N 45° W Up	140.9 87.1 31.6	6.6 6.6 1.4	3.9 1.6 0.6	55.3	5.5	VI	20 20		(19.17) (23.56)		(4.29) (6.35)		(0.19) (0.26)
B027	2nd Northwest California Earthquake, Ferndale City Hall	I	2-9-41	40°54' N 125°24' W	S 45° W N 45° W Up	61.3 38.4 19.2	3.5 3.4 2.1	2.0 2.2 1.9	98.4	6.6	VI							
B028	Western Washington Earthquake, District Engineers Office at Army Base	A	4-13-49	46°06' N 122°42' W	S 02° W N 88° W Up	66.5 65.9 22.0	8.2 7.9 2.4	2.4 2.7 2.3	57.8	7.1	VIII	40 65		(126.89) (100.39)		(54.19) (30.49)		(1.81) (0.58)
B029	Western Washington Earthquake, Olympia, Washington, Highway Test Laboratory	A	4-13-49	46°06' N 122°42' W	S 04° E S 86° W Up	161.6 274.6 90.6	21.4 17.0 6.8	8.5 10.4 4.0	16.8	7.1	VIII	50 26	131.24	(249.95) (131.66)	28.78	(63.19) (33.78)	0.12	(1.13) (0.66)
B030	Northern California Earthquake, Ferndale City Hall	I	9-22-52	40°12' N 124°25' W	S 44° W N 46° W Up	53.1 74.1 29.2	6.9 4.7 3.0	2.0 1.9 1.5	43.2	5.5	VI							
B031	Wheeler Ridge, California Earthquake, Taft Lincoln School Tunnel	A	1-12-54	35°00' N 119°01' W	N 21° E S 69° E Up	63.9 66.8 35.5	5.8 3.6 2.4	1.7 1.1 2.9	43.0	5.9	VII	20		(21.37)		(5.05)		(0.32)
B032	Puget Sound, Washington Earthquake, Olympia, Washington, Highway Test Laboratory	A	4-29-65	47°24' N 122°18' W	S 04° E S 86° W Up	134.2 194.3 59.9	8.0 12.7 3.0	2.7 3.8 1.7	61.1	6.5	VII	50 32	67.9	(62.0) (73.7)	14.8	(15.98) (18.2)	0.16	(0.24) (0.53)
B033	Parkfield, California Earthquake, Cholame, Shandon Array No. 2	A	6-27-66	35°54' N 120°54' W	N 65° E Down	479.6 202.2	77.9 14.1	26.3 4.3	31.9	5.6	VII	14 12	353.0	(253.3) (42.97)	68.3	(67.1) (13.86)	1.14	(8.48) (0.22)
B034	Parkfield, California Earthquake, Cholame, Shandon Array No. 5	A	6-27-66	35°54' N 120°54' W	N 05° W N 85° E Down	347.8 425.7 116.9	22.5 25.4 6.8	5.2 7.1 3.4	32.4	5.6	VI	15 22	64.41	(42.36) (66.5)	13.3	(11.64) (16.37)	0.066	(1.31) (1.09)
B035	Parkfield, California Earthquake, Cholame, Shandon Array No. 8	A	6-27-66	35°54' N 120°54' W	N 50° E N 40° W Down	232.6 269.6 77.7	10.8 11.8 4.5	4.4 3.9 2.1	34.1	5.6	VI	26 20	40.10	(40.77) (47.43)	7.69	(6.47) (9.44)	0.16	(0.10) (0.41)
B036	Parkfield, California Earthquake, Cholame, Shandon Array No. 12	A	6-27-66	35°54' W 120°54' W	N 50° E N 40° W Down	52.1 63.2 44.6	7.0 8.0 5.0	4.1 5.7 2.6	36.5	5.6	VI	40	70.08	(80.20)	13.57	(18.63)	0.004	(0.14)

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A =					
													0.02		0.1		0.5	
B037	Parkfield, California Earthquake Temblor No. 2	NR	6-27-66	35°54' N 120°54' W	N 65° W S 25° W Down	264.3 340.8 129.8	14.5 22.5 4.4	4.7 5.5 1.4	31.0	5.6	VII	25 22	 31.94	(32.30) (47.24)	 8.32	(7.40) (10.84)	 0.24	(0.91) (0.80)
B038	Parkfield, California Earthquake, San Luis Obispo Recreation Building	I	6-27-66	35°54' N 120°54' W	N 36° W S 54° W Up	14.2 11.4 6.1	1.1 0.8 1.3	1.2 0.6 0.9	76.1	5.6	V	29	10.38	(9.24)	1.85	(1.64)	0.024	(0.028)
B039	2nd Northern California Earthquake, Eureka Federal Building	I	12-10-67	40°30' N 124°36' W	S 11° E N 79° E Down	20.4 19.5 7.7	2.3 2.8 1.5	0.9 1.4 1.3	50.6	5.8	V	 29	 8.845	 (7.96)	 1.65	 (1.73)	 0.088	 (0.032)
B040	Borrego Mountain Earthquake, San Onofre SCE Power Plant	I	4-8-68	33°09' N 116°08' W	N 33° E N 57° W Down	40.0 45.5 54.2	3.7 4.2 3.5	1.6 2.9 1.7	134.4	6.5	V	 40	 23.22	 (20.00)	 3.88	 (4.96)	 0.012	 (0.136)
C041	*San Fernando Earthquake*, Pacoima Dam	NR	2-9-71	34°24' N 118°23'42" W	S 16° E S 74° W Down	1148.1 1054.9 696.0	113.2 57.7 58.3	37.7 10.8 19.3	9.1	6.6	X	16 14	387.3 234.2	(264.5) (170.7)	77.01 62.80	(87.06) (54.28)	0.11 1.48	(1.45) (0.76)
C042	San Fernando Earthquake, Aftershock at 52.6 sec, *Pacoima Dam*		2-9-71	34°24' N 118°23'42" W	S 74° W S 16° E Down	27.1 20.7 8.2	2.9 1.5 1.1	1.7 0.9 1.0										
C044	San Fernando Earthquake, Aftershock at 104.6 sec, Pacoima Dam		2-9-71	34°24' N 118°23'42" W	S 74° W S 16° E Down	109.9 113.2 40.5	4.8 4.7 1.8	2.2 2.3 1.0										
C048	San Fernando Earthquake, 8244 Orion Boulevard, 1st Floor, Holiday Inn	A	2-9-71	34°24' W 118°23'42" W	N 00° W S 90° W Down	250.0 131.7 167.5	30.0 23.9 32.0	14.9 13.8 14.6	22.4	6.6	VII	41 41	306.7	(294.5) (354.3)	97.2	(70.2) (127.9)	0.97	(2.45) (2.34)
C051	San Fernando Earthquake, 250 East First Street, Basement, Los Angeles	A	2-9-71	34°24' W 118°23'42" W	N 36° E N 54° W Down	97.8 122.7 48.0	17.1 21.9 7.8	9.2 11.6 5.8	42.8	6.6	VII	15 15 15	 143.8	(105.5) (173.6)	 32.44	(36.18) (36.35)	 1.212	(0.36) (0 12)
C054	San Fernando Earthquake, 445 Figueroa Street, Subbasement, Los Angeles	I,A	2-9-71	34°24' W 118°23'42" W	N 52° W S 38° W Down	147.1 117.0 51.7	17.4 17.3 10.7	11.8 11.8 5.1			VII	40 40 40	109.1 118.2	(109.5) (132.5)	26.76 31.72	(15.02) (35.05)	1.28 0.18	(0.74) (0.41)
D056	San Fernando Earthquake, *Old Ridge Route, Castaic*	I	2-9-71	34°24' N 118°23.7' W	N 21° E N 69° W Down	309.4 265.4 153.3	16.5 27.2 6.2	4.2 9.3 3.5	28.6	6.6	VI	30 30 30	42.06	(39.86) (68.01)	9.50	(9.59) (25.08)	0.03	(0.53) (1.36)
D057	San Fernando Earthquake, Hollywood Storage Basement	A	2-9-71	34°24' N 118°23.7' W	S 00° W N 90° E Up	103.8 148.2 49.8	17.0 19.4 6.0	8.6 13.1 3.8	37.1	6.6	VII	40 40 40	125.29 154.65	(124.18) (150.08)	37.02 47.74	(29.79) (42.15)	0.92 0.78	(1.03) (1 52)
D058	San Fernando Earthquake, Hollywood Storage P. E. Lot	A	2-9-71	34°24' N 118°23.7' W	S 00° W N 90° E Up	167.3 207.0 87.0	16.5 21.1 5.0	8.0 14.7 3.0	37.1	6.6	VII	21 21 21	82.66	(82.01) (152.27)	18.55	(14.80) (39.78)	0.43	(0.35) (1 41)
D059	San Fernando Earthquake, 1901 Avenue, The Stars Subbasement	A	2-9-71	34°24' N 118°23.7' W	N 46° W S 44° W Down	133.8 147.1 66.7	9.6 16.7 4.8	7.5 12.2 2.5	39.8	6.6	VII	55 55 55	70.73	(85.82) (132.90)	12.60	(10.88) (14.97)	0.14	(0.22) (0.07)
D062	San Fernando Earthquake, 1640 South Marengo Street, 1st Floor, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	N 38° W S 52° W Down	118.0 130.0 74.6	16.1 17.6 9.0	12.0 6.9 4.1	42.8	6.6	VII	30 30 30	 117.94	(125.43) (117.70)	 32.64	(35.36) (35.02)	 1.40	(0.79) (1.83)
D065	San Fernando Earthquake, 3710 Wilshire Boulevard, Basement, Los Angeles	A,I	2-9-71	34°24' N 118°23.7' W	S 00° W S 90° W Down	146.7 155.7 73.1	18.0 22.1 9.0	10.3 12.9 4.9	40.0		VII	17 17 17	73.76	(98.72) (163.43)	16.34	(16.12) (38.89)	0.17	(0.68) (0.72)
D068	San Fernando Earthquake, 7080 Hollywood Boulevard, Basement, Los Angeles	A	2-9-71	34°24' N 118°23.7' W	N 00° E N 90° E Down	81.2 98.0 57.2	12.6 13.3 5.6	8.1 7.2 4.2	35.0	6.6	VII							
E071	San Fernando Earthquake, Wheeler Ridge	A	2-9-71	34°24' N 118°23.7' W	S 00° W N 90° E Down	26.5 25.3 13.0	1.9 2.5 2.4	1.4 2.1 3.3	86.0	6.6	V		 13.71		 1.75		 0.05	
E072	San Fernando Earthquake, 4680 Wilshire Boulevard, Basement, Los Angeles	I	2-9-71	34°24' N 118°23.7' W	N 75° W N 15° E Down	82.2 115.0 64.8	20.8 21.5 6.9	14.7 11.7 3.2	39.5	6.6	VII	18 18 18	132.63	(161.58) (114.55)	55.79	(65.79) (36.57)	0.73	(0.47) (1.20)

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
E075	San Fernando Earthquake,	A	2-9-71	34°24' N	N 00° E	133.8	22.3	11.4	40.1	6.6	VII	22	164.64	(191.40)	38.65	(49.06)	1.70	(1.33)
	3470 Wilshire Boulevard,			118°23.7' W	S 90° W	111.8	18.5	11.6				22		(159.18)		(38.26)		(0.15)
	Subbasement, Los Angeles				Down	47.3	7.3	3.9				22						
E078	San Fernando Earthquake,	I	2-9-71	34°24' N	N 50° W	126.5	23.2	13.7	42.5	6.6	VII	17	163.38	(161.68)	33.18	(34.46)	1.99	(0.12)
	Water and Power Building,			118°23.7' W	S 40° W	169.2	16.1	8.9										
	Basement, Los Angeles				Down	67.2	10.2	6.4										
E081	San Fernando Earthquake,	I	2-9-71	34°24' N	S 08° E	213.0	9.9	7.0	32.9	6.6	VI	34		(36.94)		(3.08)		(0.05)
	Santa Felicia Dam,			118°23.7' W	S 82° W	198.3	6.2	4.6				34	20.97	(24.75)	2.61	(2.57)	0.13	(0.08)
	Outlet Works				Down	63.7	4.5	2.8				34						
E082	San Fernando Earthquake,		2-9-71	34°24' N	S 15° E	203.3	22.2	7.1	32.8	6.6	VI	37		(213.32)		(67.63)		(2.90)
	Santa Felicia Dam,			118°23.7' W	S 75° W	174.0	18.1	5.3				37	110.70	(109.39)	31.63	(34.64)	1.69	(1.20)
	Crest				Down	65.0	6.2	2.8				37						
E083	San Fernando Earthquake,	A	2-9-71	34°24' N	S 00° W	158.2	18.3	9.0	40.0	6.6	VII	25	103.51	(107.32)	29.21	(26.24)	0.80	(0.86)
	3407 6th Street, Basement,			118°23.7' W	N 90° E	161.9	16.5	10.3				25		(98.03)		(21.02)		(0.42)
	Los Angeles				Down	55.5	8.8	4.4				25						
F086	San Fernando Earthquake,	A	2-9-71	34°24' N	N 83° W	104.6	17.4	14.8	49.4	6.6	V		190.16	(132.27)	38.49	(30.68)	1.47	(0.23)
	Vernon, CMD Building			118°23.7' W	S 07° W	80.5	15.1	10.7										
					Up	42.7	6.7	4.0										
F087	San Fernando Earthquake,	A	2-9-71	34°24' N	S 04° E	26.8	5.0	3.6	88.5	6.6	VI			(88.33)		(22.10)		(0.11)
	Engineering Building,			118°23.7' W	S 86° W	28.2	8.0	5.7					130.95	(121.6)	37.67	(31.77)	0.31	(0.20)
	Santa Ana, Orange County				Up	16.7	2.4	1.7										
F088	San Fernando Earthquake,	A,I	2-9-71	34°24' N	S 70° E	265.7	30.7	11.1	34.1	6.6	VII	27		(153.59)		(61.36)		(2.34)
	633 East Broadway, Municipal			118°23.7' W	S 20° W	209.1	23.5	5.3				27	156.08	(179.32)	66.55	(62.85)	2.61	(1.98)
	Service Building, Glendale				Down	131.5	15.6	5.6				27						
F089	San Fernando Earthquake,	A	2-9-71	34°24' N	S 53° E	131.9	20.8	14.5	44.0	6.6	VII	22						
	808 South Olive Street,			118°23.7' W	S 37° W	139.0	20.7	11.6				22	119.60	(122.68)	29.28	(26.51)	0.12	
	Los Angeles				Down	75.3	9.9	6.0										
F092	San Fernando Earthquake,	I	2-9-71	34°24' N	S 62° E	64.2	13.8	10.3	43.1	6.6	VII			(104.71)		(24.62)		(0.53)
	2011 Zonal Avenue, Basement,			118°23.7' W	S 28° W	79.1	11.5	6.3						(68.54)		(23.40)		(0.16)
	Los Angeles				Down	48.7	7.1	3.8										
F095	San Fernando Earthquake,	A	2-9-71	34°24' N	S 88° E	96.2	16.8	10.6	37.4	6.6	VII							
	120 North Robertson Boulevard,			118°23.7' W	S 02° W	83.9	17.9	12.1						(152.37)		(55.37)		(1.90)
	Subbasement, Los Angeles				Down	26.5	6.2	3.9										
F098	San Fernando Earthquake,	A	2-9-71	34°24' N	S 53° E	236.4	21.8	13.2	42.7	6.6	VII	22	94.08	(75.18)	9.24	(14.67)	0.04	(0.42)
	646 South Olive Avenue,			118°23.7' W	S 37° W	192.0	18.5	13.4										
	Basement, Los Angeles				Down	69.2	9.6	5.3										
F101	San Fernando Earthquake,	A	2-9-71	34°24' N	S 00° W	37.5	2.5	1.1	107.6	6.6	V		6.35	(5.55)	2.56	(2.65)	0.20	(0.16)
	Edison Company, Colton			118°23.7' W	N 90° E	30.0	2.2	1.3										
					Up	19.7	1.5	1.4										
F102	San Fernando Earthquake,	HR	2-9-71	34°24' N	N 00° E	24.6	1.4	0.8	68.5	6.6	V		2.08	(2.34)	0.57	(0.58)	0.01	(0.01)
	Fort Tejon, Tejon			118°23.7' W	N 90° E	20.6	1.3	0.7						(3.41)		(1.30)		(0.05)
					Down	15.3	1.0	0.5										
F103	San Fernando Earthquake,	A	2-9-71	34°24' N	N 00° E	91.5	4.4	2.5	45.4	6.6	V							
	Pumping Plant,			118°23.7' W	N 90° W	120.5	5.4	2.4					31.33	(30.68)	8.34	(9.60)	0.15	(0.23)
	Pearblossom				Down	47.4	2.3	1.7										
F104	San Fernando Earthquake,	I	2-9-71	34°24' N	N 00° E	85.2	8.5	2.0	52.2	6.6	V							
	Oso Pumping Plant,			118°23.7' W	N 90° W	103.1	6.0	2.3					13.44	(15.39)	2.72	(2.96)	0.09	(0.02)
	Gorman				Down	35.5	3.8	1.2										
F105	San Fernando Earthquake,	A	2-9-71	34°24' N	S 00° W	83.1	8.3	4.0	38.7	6.6	VII		60.01	(49.82)	9.86	(7.21)	0.26	(0.24)
	UCLA Reactor Laboratory,			118°23.7' W	N 90° E	77.6	8.5	4.9						(52.04)		(8.65)		(0.07)
	Los Angeles				Up	67.1	4.5	2.9										
G106	San Fernando Earthquake,	HR	2-9-71	34°24'42" N	S 00° W	87.5	5.8	1.6	36.1	6.6	VII							
	CIT Seismological			118°24'00" W	S 90° W	188.6	11.6	5.0				25	31.17	(36.24)	8.20	(10.63)	0.62	(0.39)
	Laboratory, Pasadena				Down	83.5	5.7	2.3				25						
G107	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	93.5	7.9	3.0	39.8	6.6	VII	26		(63.01)		(17.48)		(0.51)
	Athenaeum, CIT			118°24'00" W	N 90° E	107.3	14.3	7.3				26	105.19	(139.12)	32.01	(33.54)	0.38	(2.00)
					Down	92.9	6.6	2.6				26						

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
G108	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	198.0	9.8	2.7	39.8	6.6	VII	35	56.12	(58.20)	11.49	(16.87)	0.01	(0.78)
	CIT Millikan Library			118°24'00" W	N 90° E	181.6	16.3	6.9				35		(91.73)		(20.33)		(0.77)
					Down	91.2	8.7	2.4				35						
G110	San Fernando Earthquake,	A,I	2-9-71	34°24'42" N	S 82° E	207.8	13.4	5.0	31.5	6.6	VII	23		(57.20)		(12.96)		(0.25)
	CIT Jet Propulsion			118°24'00" W	S 08° W	139.0	9.0	2.9				23		(33.63)		(11.07)		(0.02)
	Laboratory Basement				Down	126.3	5.7	2.6				23						
G112	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 52° W	101.9	17.0	11.0	40.5	6.6	VII	45		(101.24)		(30.06)		(0.17)
	611 West Sixth Street,			118°24'00" W	N 38° E	78.5	15.7	9.2				45	103.93	(113.98)	21.66	(21.98)	1.35	(0.18)
	Basement, Los Angeles				Down	53.2	9.9	5.2				45						
G114	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 60° E	110.8	14.0	3.8	32.3	6.6	VI	30	108.79	(126.65)	41.74	(45.81)	0.95	(0.63)
	Palmdale Fire Station			118°24'00" W	S 30° W	136.2	9.3	2.7				30		(86.10)		(21.59)		(0.03)
	Storage Room, Palmdale				Down	86.6	7.6	2.4				30						
H115	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 11° E	220.6	28.2	13.4	29.3	6.6	VII	39	271.08	(250.17)	55.15	(83.63)	0.93	(0.46)
	15250 Ventura Boulevard,			118°24'00" W	N 79° W	146.0	23.5	10.3				39		(261.37)		(74.89)		(1.24)
	Basement				Down	94.5	9.3	4.3				39						
H118	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 45° E	33.7	11.8	8.8	50.2	6.6	VI	76	281.78	(251.62)	114.86	(107.42)	1.65	(0.70)
	8639 Lincoln Avenue,			118°24'00" W	S 45° W	32.7	9.1	7.8				76		(146.62)		(47.10)		(0.68)
	Basement, Los Angeles				Down	41.0	6.9	3.9				76						
H121	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 90° W	119.4	17.1	8.6	41.1	6.6	VII	27	132.73	(113.87)	35.26	(31.34)	1.39	(0.53)
	900 South Fremont Avenue,			118°24'00" W	S 00° W	112.3	10.5	4.4				27		(72.35)		(23.56)		(0.40)
	Basement, Alhambra				Down	79.2	8.2	3.4				27						
H124	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 90° W	34.9	4.4	2.1	76.8	6.6	VI	34		(31.23)		(8.32)		(0.11)
	2600 Nutwood Avenue,			118°24'00" W	S 00° W	34.5	5.8	2.7				34	59.86	(56.65)	17.25	(20.08)	0.26	(0.57)
	Basement, Fullerton				Down	14.7	2.3	1.9				34						
I128	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	60.9	13.2	7.2				20		(128.17)		(46.34)		(2.23)
	435 North Oakhurst Avenue,			118°24'00" W	S 90° W	91.6	15.0	8.1				20		(148.85)		(47.16)		(2.11)
	Basement, Beverly Hills				Down	36.4	5.8	2.3				20						
I131	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 50° E	184.3	17.2	9.2	38.2	6.6	VI	48	84.11	(98.55)	13.32	(24.23)	0.11	(0.72)
	450 North Roxbury Drive,			118°24'00" W	N 40° W	160.6	14.1	6.1				48		(81.57)		(20.42)		(0.90)
	1st Floor, Beverly Hills				Down	37.2	4.5	2.3				48						
I134	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 54° W	97.9	16.7	11.3	38.9	6.6	VII	49		(205.96)		(47.85)		(2.36)
	1800 Century Park East,			118°24'00" W	S 36° E	82.3	10.7	6.2				49		(161.37)		(35.33)		(1.86)
	Basement (P3), Los Angeles				Down	62.5	5.7	2.5				49						
I137	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 81° E	140.2	16.1	7.1	29.0	6.6	VII	39		(165.10)		(72.66)		(1.92)
	15910 Ventura Boulevard,			118°24'00" W	S 09° W	129.0	22.3	8.4				39	235.53	(121.04)	101.38	(43.94)	0.46	(1.23)
	Basement, Los Angeles				Down	99.9	7.9	2.6				39						
J141	San Fernando Earthquake,	HR	2-9-71	34°24'42" N	N 21° E	145.5	18.0	3.4	29.6	6.6	VI	22	87.29	(88.40)	27.38	(24.71)	0.84	(2.04)
	Lake Hughes Array No. 1			118°24'00" W	S 69° E	108.9	14.4	2.9				22		(55.79)		(21.89)		(0.34)
					Down	93.0	11.7	2.9				22						
J142	San Fernando Earthquake,	HR	2-9-71	34°24'42" N	S 69° E	168.2	5.3	1.2	26.8	6.6	VI	37		(13.87)		(3.39)		(0.05)
	Lake Hughes Array No. 4			118°24'00" W	S 21° W	143.5	8.6	1.7				37	22.57	(26.33)	5.97	(4.00)	0.14	(0.36)
					Down	150.8	6.8	1.6				37						
J143	San Fernando Earthquake,	HR	2-9-71	34°24'42" N	N 21° E	119.3	4.8	2.0	26.6	6.6	VI	27	13.71	(13.20)	3.86	(3.99)	0.17	(0.04)
	Lake Hughes Array No. 9			118°24'00" W	N 69° W	109.4	4.3	2.4				27		(9.32)		(2.12)		(0.04)
					Down	71.5	2.9	2.2				27						
J144	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 21° E	346.2	14.7	1.8	23.3	6.6	VI	22		(36.57)		(12.10)		(0.43)
	Lake Hughes Array No. 12			118°24'00" W	N 69° W	277.9	12.4	8.9				22	30.15	(27.99)	8.63	(8.29)	0.76	(0.66)
					Down	105.3	4.1	3.3				22						
J145	San Fernando Earthquake,	A	2-9-71	34°24' N	S 00° W	113.9	31.5	17.5	34.9	6.6	VII	40	424.25	(411.18)	181.20	(160.29)	6.01	(3.57)
	15107 Van Owen Street,			118°23'42" W	S 90° W	103.4	28.8	15.3				40		(310.43)		(126.74)		(5.13)
	Basement, Los Angeles				Down	106.4	18.1	7.0				40						
J148	San Fernando Earthquake,	A,I	2-9-71	34°24' N	N 00° E	107.6	16.2	7.3	39.9	6.6	VII	19		(93.17)		(32.19)		(0.78)
	616 South Normandie Avenue,			118°23'42" W	S 90° W	112.0	17.5	11.1				19	108.28	(128.51)	36.36	(43.20)	1.31	(0.41)
	Basement, Los Angeles				Down	51.6	6.7	3.4				19						
L166	San Fernando Earthquake,	I	2-9-71	34°24' N	N 00° E	164.2	12.3	4.9	30.8	6.6	VII	26		(32.80)		(5.98)		(0.16)
	3838 Lankershim Boulevard,			118°23'42" W	S 90° W	147.6	15.0	5.4				26	54.26	(67.07)	16.00	(12.95)	1.23	(0.13)
	Basement, Los Angeles				Down	69.7	5.0	2.4				26						

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for H/A = 0.02		0.1		0.5	
L171	San Fernando Earthquake,	I	2-9-71	34°24' N	N 33° E	12.0	1.8	2.1	139.8	6.6	V	52		(35.18)		(8.23)		(0.04)
	Nuclear Power Plant,			118°23'42" W	N 57° W	15.9	2.8	2.1				52	16.07	(19.77)	2.56	(3.64)	0.03	(0.04)
	San Onofre				Down	10.3	1.5	2.0				52						
N176	San Fernando Earthquake,	A	2-9-71	34°24' N	N 37° E	83.4	20.9	13.7	42.9	6.6	VII	33	205.31	(214.21)	66.51	(72.27)	1.36	(1.57)
	1150 South Hill Street,			118°23'42" W	S 53° E	116.0	17.7	13.7				33		(130.44)		(24.30)		(0.45)
	Subbasement, Los Angeles				Down	41.6	8.9	4.3				33						
N179	San Fernando Earthquake,	I	2-9-71	34°24' N	S 00° W	20.8	1.1	0.7	70.7	6.6	VI	13		(3.05)		(0.55)		(0.004)
	Tehachapi Pumping Plant,			118°23'42" W	N 90° E	46.7	2.6	0.9				13	4.48	(5.03)	1.23	(1.10)	0.06	(0.04)
	CWR Site, Grapevine				Down	38.5	2.0	1.2				13						
N180	San Fernando Earthquake	A	2-9-71	34°24' N	S 00° W	23.9	5.7	3.5	84.3	6.6	V	95		(78.98)		(20.39)		(0.28)
	4000 West Chapman Avenue,			118°23'42" W	S 90° W	29.9	8.5	6.5				95	208.77	(196.69)	62.10	(66.93)	0.16	(0.19)
	Basement, Orange				Down	18.2	3.9	2.5				95						
N183	San Fernando Earthquake,	I	2-9-71	34°24' N	N 65° W	42.4	3.8	1.2	70.8	6.6	V	20	17.13	(23.32)	5.68	(6.47)	0.22	(0.09)
	6074 Park Drive, Ground			118°23'42" W	N 25° E	55.7	2.6	0.9				20		(12.29)		(4.13)		(0.06)
	level, Wrightwood				Down	22.9	2.0	1.2				20						
N184	San Fernando Earthquake,	I	2-9-71	34°24' N	N 65° E	43.1	4.6	1.2	70.8	6.6	V	26	30.53	(19.53)	7.70	(6.28)	0.09	(0.31)
	6074 Park Drive, Ground			118°23'42" W	S 25° W	57.2	2.9	0.7				26		(14.98)		(4.21)		(0.16)
	level, Wrightwood				Down	24.7	1.8	0.9				26						
N185	San Fernando Earthquake,	I	2-9-71	34°24'42" N	S 50° E	67.3	3.3	1.7	75.6	6.6	V	40		(25.24)		(6.48)		(0.18)
	Carbon Canyon Dam			118°24'00" W	S 40° W	67.3	4.5	2.1				40	28.34	(27.89)	8.27	(8.24)	0.43	(0.27)
					Down	41.5	2.5	1.6				40						
N186	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 37° E	95.7	8.8	4.9	54.1	6.6	VI	45		(71.77)		(9.30)		(0.15)
	Whittier Narrows Dam			118°24'00" W	S 53° W	94.7	9.7	5.0				45	86.14	(82.26)	11.52	(12.61)	0.26	(0.42)
					Down	58.6	3.6	2.3				45						
N187	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 75° W	55.7	3.1	0.7	72.1	6.6	VI	25	18.39	(17.23)	6.91	(6.46)	0.31	(0.24)
	San Antonio Dam,			118°24'00" W	N 15° E	75.9	3.7	0.8				25		(20.02)		(7.05)		(0.30)
	Upland				Down	28.3	1.5	0.8				25						
N188	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 54° E	114.4	17.0	10.8	38.9	6.6	VII	45	108.37	(129.59)	14.39	(27.5)	0.17	(0.42)
	1880 Century Park East, Park-			118°24'00" W	N 36° W	126.5	12.1	5.4				45		(104.39)		(20.83)		(1.15)
	ing, 1st level, Los Angeles				Down	62.5	5.0	2.4				45						
N191	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 65° E	24.7	4.1	2.6	67.8	6.6	VI	65		(97.72)		(22.25)		(24.50)
	2516 Via Tejon, Ground level,			118°24'00" W	S 25° E	40.1	5.0	3.4				65		(84.10)		(12.71)		(0.21)
	Palos Verdes Estates				Down	18.9	2.2	1.4				65						
N192	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 29° E	96.7	14.8	7.7	40.7	6.6	VII	25		(114.39)		(35.10)		(0.38)
	2500 Wilshire Boulevard,			118°24'00" W	N 61° W	98.9	19.5	7.9				25	91.12	(128.41)	27.29	(36.52)	0.46	(1.53)
	Basement, Los Angeles				Down	42.5	7.7	3.3				25						
N195	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 57° W	31.0	4.6	2.4	122.6	6.6	V	99		(56.44)		(17.33)		(0.32)
	San Juan Capistrano			118°24'00" W	N 33° E	40.9	3.6	2.4				99	44.42	(47.24)	13.46	(12.61)	0.09	(0.26)
					Down	21.0	3.4	1.6				99						
N196	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 76° W	35.0	9.5	8.0	75.4	6.6	VI	50	158.84	(154.45)	50.28	(58.27)	0.82	(0.61)
	Long Beach State College,			118°24'00" W	S 14° W	31.2	9.3	6.7				50		(190.72)		(60.70)		(1.19)
	Ground level				Down	25.8	4.9	3.8				50						
N197	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 45° E	25.6	2.2	1.2	185.0	6.6	V	43		(20.68)		(4.80)		(0.14)
	Anza Post Office			118°24'00" N	N 45° W	35.4	2.6	1.0				43	18.23	(17.33)	5.23	(5.21)	0.17	(0.19)
	Storage Room, Anza				Down	14.0	1.4	1.1				43						
O198	San Fernando Earthquake,	NR	2-9-71	34°24'42" N	S 00° W	176.0	20.5	7.28	34.0	6.6	VII	23	89.06	(85.24)	17.43	(22.20)	0.97	(0.83)
	Griffith Park Observatory,			118°24'00" W	S 90° W	167.0	14.5	5.45				23		(94.17)		(34.11)		(1.04)
	Los Angeles				Down	120.0	7.42	3.38				23						
O199	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 28° E	137.0	17.60	9.78	42.0	6.6	VII	30		(126.61)		(28.71)		(0.18)
	1625 Olympic Boulevard,			118°24'00" W	N 62° W	238.0	21.30	10.30				30	118.95	(180.90)	28.40	(32.40)	1.0103	(0.68)
	Los Angeles				Down	148.0	10.40	5.74				30						
O204	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	25.9	8.17	5.81	73.8	6.6	VI	69		(201.53)		(68.29)		(0.23)
	205 West Broadway,			118°24'00" W	N 90° E	20.7	9.58	7.27				69	266.90	(299.71)	117.04	(135.66)	3.50	(1.01)
	Long Beach				Up	12.2	6.12	3.58				69						
O205	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 21° W	28.4	7.37	6.39	73.6	6.6	VI	60		(225.87)		(62.92)		(0.43)
	Terminal Island,			118°24'00" W	S 69° W	28.1	10.30	8.72				60	222.75	(287.31)	95.89	(94.38)	1.35	(0.33)
	Long Beach				Up	16.1	4.24	2.83				60						

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for H/A = 0.02		0.1		0.5	
0206	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	37.4	3.45	1.30	108.2	6.6	VI	53	30.77	(32.62)	6.96	(6.52)	0.24	(0.17)
	Hall of Records,			118°24'00" W	N 90° E	43.9	2.86	1.05				53		(25.32)		(5.29)		(0.09)
	San Bernardino				Down	18.5	1.52	0.80				53						
0207	San Fernando Earthquake,	NR	2-9-71	34°24'42" N	N 56° E	64.6	3.84	1.23	32.8	6.6	VI	20		(12.2)		(3.03)		(0.27)
	Fairmont Reservoir,			118°24'00" W	N 34° W	97.0	8.35	1.71				20	15.95	(24.87)	4.09	(5.75)	0.21	(0.23)
	Fairmont				Up	32.90	3.37	1.73				20						
0208	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 42° E	16.40	2.69	1.65			V	62		(53.21)		(16.01)		(0.41)
	University of California,			118°24'00" W	S 48° E	17.00	3.67	2.32				62		(95.47)		(35.89)		(1.03)
	Santa Barbara				Up	11.00	1.69	1.45				62						
0210	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 45° E	34.90	2.86	1.66		6.6	V	52		(24.72)		(4.49)		(0.04)
	Fire Station, Hemet			118°24'00" W	S 45° W	38.40	2.74	1.32				52		(15.60)		(3.55)		(0.08)
					Down	25.00	2.33	1.25				52						
0213	San Fernando Earthquake,	NR	2-9-71	34°24'42" N	S 45° E	0.65	0.27	0.21	378.3	6.6	III	28		(1.79)		(0.81)		(0.01)
	1215 Gallery, Hoover Dam			118°24'00" W	S 45° W	1.23	0.29	0.19				28		(2.23)		(0.60)		(0.007)
					Up	0.86	0.55	0.71				28						
P214	San Fernando Earthquake,	I	2-9-71	34°24'42" N	S 89° W	154.00	23.20	8.02	36.2	6.6	VII	15	91.92	(140.85)	36.69	(32.85)	2.41	(0.59)
	4867 Sunset Boulevard,			118°24'00" W	S 01° E	156.00	16.20	7.94				15		(97.06)		(27.92)		(0.60)
	Los Angeles				Down	115.00	9.84	5.15				15						
P217	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 00° W	108.00	14.70	9.94	40.0	6.6	VII	35	125.85	(110.44)	37.81	(29.81)	0.68	(0.90)
	3345 Wilshire Boulevard,			118°24'00" W	N 90° E	88.10	16.10	9.09				35		(177.12)		(49.42)		(0.88)
	Los Angeles				Down	60.10	7.07	4.61				35						
P220	San Fernando Earthquake,	I	2-9-71	34°24'42" N	S 00° W	24.10	7.01	6.92	95.8	6.6	VI	60		(122.95)		(37.10)		(0.20)
	666 West 19th Street,			118°24'00" W	N 90° E	34.30	5.78	6.70				60	145.61	(138.30)	28.63	(27.75)	0.51	(0.48)
	Costa Mesa				Down	9.29	3.47	2.32				60						
P221	San Fernando Earthquake,	NR	2-9-71	34°24'42" N	N 03° E	137.00	5.29	3.15	43.3	6.6	VI	28		(8.84)		(2.71)		(0.08)
	Santa Anita Reservoir,			118°24'00" W	N 87° W	165.00	6.66	5.91				28	13.33	(13.87)	3.65	(4.70)	0.09	(0.16)
	Arcadia				Down	47.60	4.46	2.46				28						
P222	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 00° W	25.90	7.25	4.54	79.3	6.6	VI	58	146.11	(183.46)	59.86	(62.50)	0.75	(0.99)
	Navy Laboratory,			118°24'00" W	S 90° W	25.20	5.51	4.92				58		(107.82)		(36.14)		(0.37)
	Port Hueneme				Up	10.40	3.19	2.17				58						
P223	San Fernando Earthquake,	NR	2-9-71	34°24'42" N	N 55° E	69.70	4.60	2.07	65.0	6.6	V	32	21.28	(26.80)	4.64	(5.40)	0.12	(0.16)
	Puddingstone Reservoir,			118°24'00" W	N 35° W	53.20	4.39	1.82				32		(26.26)		(6.70)		(0.17)
	San Dimas				Down	37.80	2.24	1.79				32						
P231	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 00° E	41.30	10.60	8.28	51.7	6.6	VI	30		(84.88)		(28.83)		(0.40)
	9841 Airport Boulevard,			118°24'00" W	S 90° W	37.70	13.30	10.20				30	160.46	(146.39)	77.88	(75.54)	0.46	(0.84)
	Los Angeles				Up	17.90	5.68	3.47				30						
Q233	San Fernando Earthquake,	A	2-9-71	34°24'42" N	S 12° W	243.00	31.50	18.30	29.3	6.6	VII	36	224.99	(255.61)	57.98	(52.26)	1.47	(2.32)
	14724 Ventura Boulevard,			118°24'00" W	N 78° W	197.00	17.80	9.46				36	127.70	(164.04)	31.68	(30.55)	0.88	(0.19)
	Los Angeles				Up	96.00	9.65	3.82				36						
Q236	San Fernando Earthquake,	A	2-9-71	34°24'42" N	South	167.00	13.40	6.13	34.9	6.6	VII	30	85.58	(67.73)	17.84	(13.87)	0.45	(0.52)
	1760 North Orchid Avenue,			118°24'00" W	East	122.00	10.30	5.85				30		(48.69)		(8.34)		(0.21)
	Los Angeles				Up	73.20	7.49	1.87				30						
Q239	San Fernando Earthquake,	A	2-9-71	34°24'42" N	South	119.00	17.20	9.79	38.0	6.6	VII	36	136.23	(129.27)	33.81	(27.34)	1.31	(0.57)
	9100 Wilshire Boulevard,			118°24'00" W	East	161.00	19.10	11.60				36	144.33	(150.68)	26.28	(24.24)	0.72	(0.13)
	Los Angeles				Up	40.50	7.16	2.88				36						
Q241	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 37° E	86.80	17.90	9.22	41.8	6.6	VII	25	126.98	(151.34)	41.34	(49.46)	1.10	(1.80)
	800 West First Street,			118°24'00" W	N 53° W	138.00	19.60	9.98				25	132.22	(128.33)	30.06	(22.82)	1.05	(0.00)
	Los Angeles				Up	60.80	8.73	5.08				25						
R244	San Fernando Earthquake,	A or I	2-9-71	34°24'42" N	N 53° W	149.00	18.30	9.80	41.9	6.6	VII	20	92.15	(91.25)	22.02	(15.95)	0.80	(0.02)
	222 Figueroa Street,			118°24'00" W	S 37° W	126.00	18.70	9.93				20		(97.41)		(27.47)		(0.63)
	Los Angeles				Up	43.20	8.50	4.36				20						
R246	San Fernando Earthquake,	A	2-9-71	34°24'42" N	South	115.00	16.70	8.29	35.7	6.6	VII	23	103.06	(98.21)	29.58	(29.34)	0.77	(0.80)
	6464 Sunset Boulevard,			118°24'00" W	East	106.00	18.30	10.40				23		(120.68)		(31.27)		(1.42)
	Los Angeles				Up	74.10	7.07	1.99				23						
R248	San Fernando Earthquake,	A	2-9-71	34°24'42" N	South	184.00	19.70	7.68	35.7	6.6	VII	28	102.71	(95.96)	26.78	(22.35)	0.75	(0.14)
	6430 Sunset Boulevard,			118°24'00" W	East	174.00	18.20	10.20				28		(111.55)		(29.88)		(0.59)
	Los Angeles				Up	88.90	6.33	2.76				28						

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
R249	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 44° E	79.80	16.20	11.40	39.2	6.6	VII			(146.67)		(39.13)		(0.62)
	1900 Avenue of the Stars,			118°24'00" W	S 46° E	84.10	10.00	7.34						(112.36)		(25.20)		(0.68)
	Los Angeles				Up	57.30	4.56	2.03										
R251	San Fernando Earthquake,	A or I	2-9-71	34°24'42" N	N 37° E	195.00	16.70	8.93	41.8	6.6	VII	20		(111.41)		(33.32)		(0.35)
	234 South Figueroa Street,			118°24'00" W	S 53° E	188.00	18.70	9.49				20	75.51	(74.96)	13.95	(22.13)	0.07	(1.20)
	Los Angeles				Up	67.50	7.78	4.75				20						
R253	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 30° W	242.00	19.20	11.40	42.0	6.6	VII	25	106.63	(101.29)	21.02	(17.21)	0.47	(0.35)
	533 South Fremont Avenue,			118°24'00" W	S 60° W	220.00	18.00	12.40				25		(119.14)		(20.32)		(0.44)
	Los Angeles				Up	81.60	9.88	5.40				25						
S255	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 08° E	123.00	22.50	15.80	38.9	6.6	VII	21	181.92	(227.19)	54.32	(60.91)	0.61	(1.07)
	6200 Wilshire Boulevard,			118°24'00" W	N 82° W	128.00	21.90	10.90				21		(151.37)		(36.72)		(1.23)
	Los Angeles				Up	46.80	5.20	2.65				21						
S258	San Fernando Earthquake	A	2-9-71	34°24'42" N	N 29° E	56.30	17.20	10.30	44.6	6.6	VII			(180.76)		(51.49)		(1.31)
	3440 University Avenue,			118°24'00" W	S 61° E	83.30	18.50	10.50						(183.65)		(58.34)		(1.93)
	Los Angeles				Up	54.50	7.14	3.56										
S261	San Fernando Earthquake,	A	2-9-71	34°24'42" N	N 59° E	97.70	18.30	12.20	39.6	6.6	VII	39	146.70	(159.04)	41.47	(40.79)	0.61	(0.61)
	1177 Beverly Drive,			118°24'00" W	N 31° W	107.00	11.20	5.92				39		(55.80)		(7.50)		(0.25)
	Los Angeles				Up	64.00	4.95	2.26				39						
S262	San Fernando Earthquake,	I	2-9-71	34°24'42" N	N 83° W	68.30	25.70	16.50	39.0	6.6	VII	25	208.88	(280.44)	97.67	(120.88)	2.99	(2.90)
	5900 Wilshire Boulevard,			118°24'00" W	S 07° W	93.60	27.80	13.70				20	209.72	(180.82)	74.31	(66.88)	2.80	(0.41)
	Los Angeles				Up	32.90	6.17	2.74				20						
S265	San Fernando Earthquake,	I	2-9-71	34°24'42" N	South	104.00	17.80	8.69	39.9	6.6	VII	21		(109.37)		(26.50)		(0.48)
	3411 Wilshire Boulevard,			118°24'00" W	West	125.00	18.20	12.60				21	113.41	(138.85)	29.41	(21.19)	0.23	(0.13)
	Los Angeles				Up	53.70	6.79	3.56				21						
S266	San Fernando Earthquake,	A	2-9-71	34°24'42" N	North	153.00	17.50	8.04	40.0	6.6	VII	30		(124.30)		(28.02)		(0.58)
	3550 Wilshire Boulevard,			118°24'00" W	West	129.00	21.40	11.60				30	133.48	(188.50)	45.79	(38.34)	0.56	(0.60)
	Los Angeles				Up	54.20	7.08	3.15				30						
S267	San Fernando Earthquake,	A	2-9-71	34°24'42" N	North	55.50	13.50	8.49	52.0	6.6	VI	49	110.99	(123.47)	32.18	(38.74)	0.49	(0.39)
	5260 Century Boulevard,			118°24'00" W	East	61.50	13.80	9.38				49	144.92	(216.14)	38.70	(62.55)	0.15	(0.30)
	Los Angeles				Up	25.40	5.42	3.64				49						
T286	El Centro, Imperial Valley	A	10-21-71	32°58'00" N	North	58.40	6.22	4.24	46.5	6.5	VI	30	75.32	(18.48)	20.07	(3.44)	0.17	(0.07)
	Irrigation District			116°00'00" W	East	46.50	6.05	3.33				30		(42.66)		(10.23)		(0.55)
					Up	25.10	1.58	0.79				30						
T287	El Centro, Imperial Valley	A	1-23-51	32°59'00" N	North	30.30	2.98	1.95	27.5	5.6	VI	30	20.28	(15.94)	4.95	(3.48)	0.17	(0.26)
	Irrigation District			115°44'00" W	East	27.50	3.09	1.00				30		(7.81)		(1.45)		(0.01)
					Up	13.20	1.21	0.89				30						
T288	El Centro, Imperial Valley	A	6-13-53	32°57'00" N	North	7.21	1.39	1.31	23.6	5.5	V	30		(46.70)		(7.69)		(0.12)
	Irrigation District			115°43'00" W	East	35.80	6.32	1.51				30	55.89	(135.00)	14.61	(27.22)	0.70	(0.35)
					Up	16.80	0.88	0.98				30						
T289	El Centro, Imperial Valley	A	11-12-54	31°30'00" N	North	24.10	3.76	0.99	149.8	6.3	IV	30		(34.02)		(10.67)		(0.35)
	Irrigation District			116°00'00" W	East	27.00	3.17	2.66				30	16.07	(19.05)	5.65	(6.58)	0.11	(0.31)
					Up	6.74	0.95	1.09				30						
T292	El Centro, Imperial Valley	A	12-16-55	33°00'00" N	North	62.50	4.60	2.06	23.5	5.4	VI	30		(12.83)		(1.76)		(0.03)
	Irrigation District			115°30'00" W	East	71.00	5.16	2.19				30	24.90	(14.51)	6.03	(3.97)	0.34	(0.28)
					Up	56.40	1.54	0.62				30						
T293	El Centro, Imperial Valley	A	8-7-66	31°48'00" N	North	13.50	2.43	2.02	148.1	6.3	VI			(20.07)		(5.68)		(0.36)
	Irrigation District			114°30'00" W	East	14.70	2.40	1.66						(17.78)		(5.83)		(0.03)
					Up	4.96	1.36	1.72										
U294	City Hall, Ferndale	I	7-6-34	41°42'00" N	N 45° W	14.50	1.40	1.12	128.9		IV			(14.93)		(4.69)		(0.13)
				124°36'00" W	S 45° W	14.60	1.05	1.26						(11.15)		(2.43)		(0.06)
					Up	5.98	0.82	1.03										
U295	Federal Building,	HR	10-31-35	46°37'00" N	North	29.30	0.54	0.32	5.8		VII	12		(0.09)		(0.03)		(0.0009)
	Helena, Montana			111°58'00" W	East	25.20	0.39	0.16				12		(0.05)		(0.01)		(0.003)
					Up	7.11	0.52	0.67				20						
U297	Helena, Montana	HR	11-28-35	46°37'00" N	North	74.80	3.22	0.84	5.8	5.0	VI	21		(3.79)		(1.03)		(0.02)
	Federal Building			111°58'00" W	East	83.00	3.88	0.99				20	12.06	(6.38)	1.95	(1.83)	0.02	(0.04)
					Up	31.70	1.42	0.78				35						

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec²	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
U298	City Hall, Ferndale	I	2-6-37	40°30'00" N	N 45° W	38.40	4.07	0.90	85.1		V	55		(27.73)		(6.21)		(0.12)
				125°15'00" W	S 45° W	35.90	2.71	0.99				55		(21.60)		(3.90)		(0.06)
					Up	13.90	1.59	1.04				75						
U299	Santa Barbara Courthouse	A	6-30-41	34°22' N	N 45° E	233.00	21.70	3.74	35.9	5.9	VIII	15	17.58	(31.52)	5.45	(5.86)	0.84	(0.36)
				119°35' W	S 45° E	172.00	21.60	3.92				15		(62.93)		(13.02)		(1.22)
					Up	68.50	3.64	2.59				15						
U300	City Hall, Ferndale	I	10-3-41	40°36' N	N 45° W	118.00	6.92	2.95	29.8	6.4	VII	30	31.81	(33.23)	8.11	(8.52)	0.01	(0.21)
				124°36' W	S 45° W	113.00	5.74	2.51				30		(21.83)		(5.68)		(0.15)
					Up	37.50	2.56	1.12				30						
U301	Public Library,	A	3-9-49	37°06' N	N 89° W	193.00	11.70	1.40	29.3	5.3	VII	30(65)	25.88	(34.25)	4.96	(8.44)	0.36	(0.64)
	Hollister			121°18' W	S 01" W	119.00	8.26	1.71				(65)		(31.93)		(12.21)		(0.65)
					Up	69.50	3.63	0.96				(65)						
U305	Public Library,	A	4-25-54	36°48' N	N 89° W	52.00	4.19	2.24	36.2	5.3	VI	33	20.59	(19.73)	6.04	(6.44)	0.13	(0.11)
	Hollister			121°48' W	S 01° W	48.90	4.52	1.36				33		(32.96)		(11.15)		(0.36)
					Up	23.10	1.94	1.06				33						
U307	Public Library,	A	1-19-60	36°47' N	N 89° W	55.50	5.25	1.85	8.5	5.0	VI	35	22.59	(19.56)	6.60	(4.66)	0.09	(0.19)
	Hollister			121°26' W	S 01° W	35.30	3.64	1.21				35		(11.59)		(3.49)		(0.11)
					Up	23.60	2.10	1.08				35						
U308	City Hall, Ferndale	I	6-5-60	40°49' N	N 46° W	57.50	3.11	1.21	60.3	5.7	VI	65		(19.89)		(3.56)		(0.07)
				124°53' W	S 44° W	73.50	3.60	1.18				65	21.45	(19.59)	3.33	(2.71)	0.18	(0.015)
					Up	14.40	1.06	0.81				65						
U309	Public Library,	A	4-8-61	36°30' N	N 89° W	168.00	10.80	3.00	40.0	5.7	VII	30	26.38	(24.36)	5.90	(4.86)	0.01	(0.00)
	Hollister			121°18' W	S 01° W	74.90	6.28	1.77				30		(47.65)		(17.27)		(0.52)
					Up	60.20	4.23	1.99				30						
U310	Federal Office Building,	A	4-29-65	47°24' N	S 32° E	52.10	5.59	2.55	22.3	6.5	VIII	30		(46.18)		(14.03)		(0.77)
	Seattle, Washington			122°18' W	S 58° W	77.50	9.35	5.43				30	58.54	(54.70)	18.49	(18.38)	0.50	(0.68)
					Up	32.10	8.35	1.62				30						
U311	Lincoln School Tunnel, Taft	A	6-27-66	35°57'18" N	N 21° E	8.10	2.10	2.53	130.5	5.6	III	55		(39.63)		(10.12)		(0.14)
	Parkfield Earthquake			120°29'54" W	S 69° E	11.20	2.21	1.49				55	29.82	(26.16)	7.98	(6.58)	0.17	(0.09)
					Up	5.95	1.10	1.50				55						
U312	City Hall, Ferndale	I	12-10-67	40°30' N	N 46° W	103.00	11.80	1.76	30.6	5.8	VI	35		(50.96)		(8.38)		(0.14)
				124°36' W	S 44° W	232.00	11.90	1.66				35	14.16	(25.63)	1.22	(4.88)	0.00	(0.29)
					Up	32.40	2.69	1.00				40						
U313	Hollister	A	12-18-67	37°00'36" N	N 89° W	13.10	2.67	2.26	39.0	5.2	V	(40)		(40.65)		(8.65)		(0.12)
				121°47'18" W	S 01° W	16.20	1.74	2.03				60(40)	22.10	(17.86)	6.16	(4.89)	0.14	(0.22)
					Up	10.00	1.14	1.33				(40)						
V314	Los Angeles Subway Terminal	I,A	3-10-33	33°37' N	N 39° E	62.30	17.30	8.21	54.9	6.3	VII	80		(206.09)		(79.74)		(0.72)
	Subbasement			117°58' W	N 51° W	95.60	23.60	16.30				80	366.45	(343.14)	109.52	(90.30)	5.88	(0.99)
					Up	63.60	9.07	5.72				80						
V315	Public Utilities Building	A	3-10-33	33°37' N	South	192.00	29.40	22.70	27.2	6.3	VIII	34	205.28	(175.12)	30.61	(50.87)	0.63	(0.81)
	Long Beach			117°58' W	West	155.00	16.50	11.80				--(38)		(82.90)		(19.67)		(1.00)
					Up	279.00	30.10	26.30				30(31)						
V316	Public Utilities Building,	A	11-14-41	33°47' N	North	39.70	7.61	2.47	6.2	5.4	VI	20		(23.77)		(8.02)		(0.26)
	Long Beach			118°15' W	East	53.60	9.32	3.56				20	55.58	(68.87)	14.26	(17.82)	0.32	(1.87)
					Up	8.47	1.04	0.56				47						
V317	Los Angeles Chamber of	A	11-14-41	33°47'00" N	S 50° E	14.90	1.33	0.85	28.5	5.4	VI	60		(13.61)		(2.73)		(0.07)
	Commerce Basement			118°15'00" W	S 40° W	11.20	1.42	0.49				17		(11.27)		(4.37)		(0.11)
					Up	6.69	0.79	0.41				25						
V319	City Recreation Building,	I	11-21-52	35°50' N	N 36° W	52.90	3.35	0.80	76.1	6.0	VI	26	20.38	(19.51)	5.19	(4.92)	0.15	(0.10)
	San Luis Obispo			121°10' W	S 54° W	35.40	2.89	1.26				26		(17.55)		(4.78)		(0.18)
					Up	26.30	2.63	1.20				26						
V320	Southern Pacific Building	A	3-22-57	37°40" N	N 45° E	2.02	0.28	0.32	16.2	3.8	V							
	Basement, San Francisco			122°28' W	N 45° W	2.42	0.33	0.43										
	(Foreshock)				Up	1.52	0.33	0.46										
V322	San Francisco,	A	3-22-57	37°39'00" N	N 45° S	8.56	0.83	0.40	17.3	4.4	V							
	South Pacific Building			122°27'00" W	N 45° W	24.50	2.61	1.17										
					Up	6.05	0.88	0.88										

(Continued)

Table A1 (Continued)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec²	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
V323	San Francisco,	I	3-22-57	37°39'00" N	N 81° E	15.60	0.82	0.26	15.60	4.4	V							
	Alexander Building			122°27'00" W	N 09° W	18.50	0.98	0.72										
					Up	5.80	0.88	0.86										
V328	Southern Pacific Building	A	3-22-57	37°39' N	N 45° E	2.07	0.42	0.38	18.30	4.0	V							
	Basement, San Francisco			122°29' W	N 45° W	9.00	0.91	0.48				20	3.40		0.68		0.01	
	(Aftershock)				Up	2.79	0.54	0.51										
V329	Port Hueneme	A	3-18-57	34°07'06" N	South	163.00	17.90	4.02	5.4	4.7	VI	10		(13.56)		(4.12)		(0.80)
				119°13'12" W	West	86.80	8.85	2.61				10		(12.54)		(1.35)		(0.00)
					Up	24.70	1.93	0.48				10						
V330	Federal Building,	I	9-4-62	40°58' N	N 79° E	45.30	3.52	1.70	19.0	5.0	VI	70	11.07	(8.72)	1.39	(1.64)	0.09	(0.11)
	Eureka			124°12' W	S 11° E	47.30	2.67	1.18				70		(7.52)		(1.37)		(0.17)
					Up	12.90	1.50	2.00				70						
V331	Old Ridge Route	I	7-15-65	34°29'06" N	South	40.40	2.12	0.87	21.2	4.0	V	30(35)	1.37	(11.52)	0.36	(2.49)	0.01	(0.03)
	(CWR Site),			118°31'18" W	East	35.90	1.13	0.42				(35)		(2.03)		(0.49)		(0.01)
	Castaic				Down	26.20	0.58	0.18				(35)						
V332	Sacramento, Pacific	A	9-12-66	39°24'00" N	South	14.40	1.57	0.74	151.5	6.3	VI							
	Telephone and Telegraph			120°06'00" W	East	12.40	1.74	0.75										
					Up	8.07	0.83	0.65										
W334	6074 Park Drive,	I	9-12-70	34°16'12" N	S 65° E	139.00	8.87	2.21	13.4	5.4	VI	17		(20.88)		(8.09)		(0.31)
	Wrightwood			117°32'24" W	S 25° W	194.00	9.63	1.03				17	15.87	(7.45)	3.82	(2.77)	0.39	(0.05)
					Down	53.00	3.18	1.44				17						
W335	Cedar Springs, Allen Ranch	MR	9-12-70	34°16'12" N	S 85° E	69.80	5.55	2.42	20.8	5.4	VI	15		(3.39)		(1.58)		(0.20)
				117°32'24" W	S 05° W	54.90	1.96	2.00				15		(2.51)		(0.83)		(0.06)
					Down	59.30	2.56	1.15				15						
W336	Cedar Springs, Pump House	I	9-12-70	34°16'12" N	S 54° E	55.90	2.94	0.78	23.8	5.4	VI	10		(7.06)		(2.47)		(0.29)
	on dam abutment			117°32'24" W	S 36° W	69.40	3.96	1.21				10		(8.81)		(3.11)		(0.15)
					Down	36.90	1.25	0.36				10						
W338	Hall of Records,	A	9-12-70	34°16'12" N	North	113.00	4.75	1.75	22.9	5.4	VI	25	8.42	(9.32)	2.01	(2.49)	0.18	(0.23)
	San Bernardino			117°32'24" W	East	57.50	3.10	1.66				25		(12.21)		(2.64)		(0.23)
					Down	52.50	1.85	1.54				30						
W339	Southern California Edison	A	9-12-70	34°16'12" N	South	40.20	2.55	0.95	31.5	5.4	VI	35(42)	4.56	(4.10)	1.55	(1.53)	0.06	(0.10)
	Company, Colton			117°32'24" W	East	35.30	1.87	0.70				(42)		(8.94)		(3.28)		(0.21)
					Up	33.60	1.30	0.72				(42)						
W342	Millikan Library Basement,	A	9-12-70	34°16'12" N	North	19.30	1.53	1.74	56.0	5.4	V	24(23)	8.42	(12.01)	2.17	(2.41)	0.05	(0.06)
	CIT, Pasadena			117°32'24" W	East	18.70	1.44	1.13				(23)		(5.00)		(0.94)		(0.008)
					Down	12.30	0.68	0.52				(23)						
W344	J. P. L. Basement, Pasadena	I	9-12-70	34°16'12" N	S 82° E	14.40	1.03	1.03	58.9	5.4	V	(16)		(4.27)		(1.34)		(0.03)
				117°32'24" W	S 08° W	24.10	2.00	2.37				24(16)	4.86	(2.72)	0.53	(0.41)	0.03	(0.00)
					Down	15.40	1.86	1.44				(16)						
Y370	Southern California Edison	A	4-8-68	33°11'24" N	South	21.40	3.53	4.25	146.2	6.4	VI	81	26.49	(27.89)	4.36	(5.12)	0.05	(0.13)
	Company, Colton			116°07'42" W	East	28.10	2.71	2.11				85		(20.56)		(4.20)		(0.08)
					Up	21.40	1.80	1.07				85						
Y371	Engineering Building, Santa	A	4-8-68	33°11'24" N	S 04° E	13.10	4.38	3.47	173.1	6.4	V	82(80)	89.77	(84.93)	32.07	(29.72)	0.17	(0.51)
	Anna, Orange County			116°07'42" W	S 26° W	11.70	4.28	2.85				(80)		(57.14)		(17.84)		(0.25)
					Up	5.65	2.21	1.94				(80)						
Y372	Terminal Island, Southern	A	4-8-68	33°11'24" N	N 21° W	8.73	3.19	4.98	205.1	6.4	VI	52(50)	40.33	(37.30)	12.58	(12.35)	0.65	(0.46)
	California Edison Plant,			116°07'42" W	S 69° W	9.51	2.86	2.11				(50)		(35.52)		(9.63)		(0.02)
	Long Beach				Up	5.14	1.75	.82				(50)						
Y373	J. P. L. Basement, Pasadena	A,I	4-8-68	33°11'24" N	S 82° E	7.35	1.35	0.53	220.3	6.4	VI	30(40)	13.98	(14.95)	4.04	(4.68)	0.14	(0.18)
				116°07'42" W	S 08° W	7.02	1.32	0.96				(40)		(15.33)		(3.54)		(0.21)
					Down	4.89	0.99	0.72				(40)						
Y375	Millikan Basement, CIT,	A	4-8-68	33°11'24" N	North	9.82	2.20	1.70	212.9	6.4	VI	52		(20.84)		[illegible]		(0.13)
	Pasadena			116°07'42" W	East	10.30	2.24	1.84				52	21.97	(23.87)	8.03	(8.28)	0.20	(0.27)
					Down	6.38	1.14	0.85				52						
Y376	Pasadena, CIT Athenaeum	A	4-8-68	33°11'24" N	South	6.99	2.10	2.02	212.0	6.4	VI	60		(57.34)		(21.00)		(0.57)
				116°07'42" W	West	10.00	2.45	1.62				60		(30.07)		(10.62)		(0.05)
					Up	3.81	0.99	1.05				60						

(Continued)

Table A1 (Concluded)

CIT File No.	Recording Station	Site Classification	Date of Earthquake	Epicenter Location	Instrument Component	A Peak Acceleration cm/sec^2	V Peak Velocity cm/sec	D Peak Displacement cm	Epicentral Distance km	Richter Magnitude M	Modified Mercalli Intensity	Duration sec	Values of u (cm) for N/A =					
													0.02		0.1		0.5	
Y377	Southern California Edison	A	4-8-68	33°11'24" N	N 52° W	7.66	2.33	1.98		6.4	VI	44		(22.89)		(9.63)		(0.29)
	Building, Los Angeles			116°07'42" W	S 38° W	11.90	3.08	2.31				44		(36.74)		(11.63)		(0.58)
					Up	4.12	1.33	1.36				44						
Y378	Subway Terminal Basement,	A,1	4-8-68	33°11'24" N	S 52° E	6.97	2.23	1.07	218.8	6.4	VI	(21)		(29.18)		(14.12)		(0.90)
	Los Angeles			116°07'42" W	S 38° W	11.40	3.07	2.30				30(21)	33.23	(27.36)	10.41	(9.75)	0.06	(0.62)
					Up	5.41	1.23	1.01				(21)						
Y379	CMD Building, Vernon	A	4-8-68	33°11'24" N	N 83° W	18.40	4.27	2.50	212.2	6.4	VI	(62)		(119.20)		(32.50)		(0.19)
				116°07"42" W	S 07° W	18.50	4.65	2.69				60(62)	61.47	(56.80)	19.86	(14.84)	0.32	(0.32)
					Up	6.97	2.38	1.47				(62)						
Y380	Hollywood Storage *P. E. Lot*,	A	4-8-68	33°11'24" N	South	10.90	2.42	2.12	227.3	6.4	VI	51		(29.76)		(10.96)		(0.62)
	Los Angeles			116°07'42" W	East	12.30	3.18	1.38				51	40.69	(55.24)	13.72	(20.55)	0.38	(0.73)
					Up	4.79	1.11	1.06				51						
	Oroville, California, Earth-	R	8-1-75	39°26'24" N	N 53° W	81.50	-5.00	-1.60	12.0	5.7	VII	12	6.28	(13.06)	2.11	(4.23)	0.19	(0.15)
	quake, Oroville Dam			121°31'48" W	N 37° E	90.90	4.50	1.30				12	3.49	(2.82)	0.73	(0.84)	0.01	(0.04)
					Up	117.00	-5.30	-2.70				12						
	Niigata Earthquake, Perfecture	A	6-16-64	38°24'00" N	N S	135.40	12.69	2.95	120.0	7.5	VI+	38	23.79	(39.85)	7.98	(11.01)	0.02	(0.15)
	Building, Akita, Japan			139°12'00" E	E W	157.97	17.33	2.91				38	15.55	(31.02)	4.35	(6.04)	0.10	(0.00)
					V	45.87	4.56	4.65				38						
	Koyna Earthquake,	R	12-10-67	17°22'12" N	T	447.66	36.42	3.28	5.0	6.5	VIII	11	14.84	(17.10)	4.01	(4.65)	0.29	(0.55)
	Koyna Dam, India			73°42'00" E	L	619.35	45.5	2.55				11	13.78	(13.09)	4.48	(3.11)	0.07	(0.04)
					V	333.20												
	Gazli Earthquake,	A	5-17-76	40°36'00" N	N S	609.22	9.06	27.31	10.0	7.3(MS)	IX	13.5	269.23	(237.77)	63.78	(83.06)	1.63	(2.00)
	U.S.S.R.			63°24'00" E	E W	716.66	12.45	50.99		6.5(m_b)		13.0	211.20	(260.97)	64.66	(74.89)	0.79	(1.95)
					V	1327.45	69.65	54.47				13.8						
	Bucharest Earthquake,	A	3-4-77	45°52'12" N	E W	-174.54	5.35	10.60	166.0	7.2	VIII	16.2	187.76	(185.93)	63.40	(74.98)	1.95	(4.38)
	Romania			26°45'00" E	N S	201.75	2.69	20.06				16.1	341.14	(676.70)	123.03	(170.57)	18.73	(21.53)
					Up	107.05	12.50	-3.01				16.1						
	Imperial Valley Earthquake	A	10-15-79		315°	213.1	-48.4	-22.3		6.6			317.57	(240.44)	83.40	(58.65)	1.88	(1.71)
	Holtville Post Office				225°	-246.2	-44.7	+25.3		6.6			283.73	(242.34)	71.49	(86.04)	0.43	(3.01)
	El Centro Array #10	A	10-15-79		50°	-168.2	44.3	-27.1		6.6			284.87	(343.32)	86.37	(66.83)	3.89	(1.71)
	Keystone Rd.				320°	-221.7	42.2	16.7		6.6			273.03	(202.26)	59.18	(65.31)	1.17	(4.72)
	El Centro Array #3	A	10-15-79		230°	218.1	36.8			6.6			208.46	(165.07)	38.98	(32.04)	0.88	(0.57)
	Pine Union School				140°	261.7	46.32			6.6			190.9	(298.1)	58.9	(63.3)	0.65	(3.67)

Table A2
Synthetic Earthquake Records

Simulated Earthquake Type	Approximate Magnitude	A Maximum Acceleration cm/sec^2	V Maximum Velocity cm/sec	D Maximum Displacement cm	$\frac{AD}{V^2}$	$\frac{V^2}{AD}$	Approximate Predominant Period sec	Total Duration sec	Values of u (cm) for N/A = 0.02		0.1		0.5	
CIT* A-1	8+	382.77	58.99	39.83	4.38	0.228	0.50	120	1501.85	(1570.95)†	453.64	(439.10)†	15.72	(8.09)†
A-2	8+	441.64	55.05	72.97	10.63	0.094	0.35	120	1409.44	(1409.44)	389.07	(391.81)	2.53	(5.55)
B-1	7	368.12	45.72	33.17	5.84	0.171	0.20	50	595.09		169.78		3.57	
B-2	7	308.70	48.26	22.22	2.94	0.339	0.22	50	492.66		159.19		5.13	
C-1	6	66.93	6.65	1.36	2.06	0.486	0.15	12	22.59		9.91		0.82	
C-2	6	57.23	6.09	0.88	1.36	0.736	0.20	12	26.89		9.91		0.46	
D-1	5	470.40	26.67	4.88	3.23	0.310	0.15	10	80.89		24.49		1.54	
D-2	5	490.00	28.94	6.84	4.00	0.245	0.15	10	74.69		17.60		0.59	
Seed-Idriss**	8-1/4	412.21	57.76	--	--	--	0.40	73	1256.10	(1269.86)	451.61	(424.90)	8.01	(11.65)
NRC		343.00	51.40						345.84		133.25		3.62	

* Jennings, Housner, and Tsai (1968).
** Seed and Idriss (1969).
† Values in parentheses are for reversed direction of shaking.

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